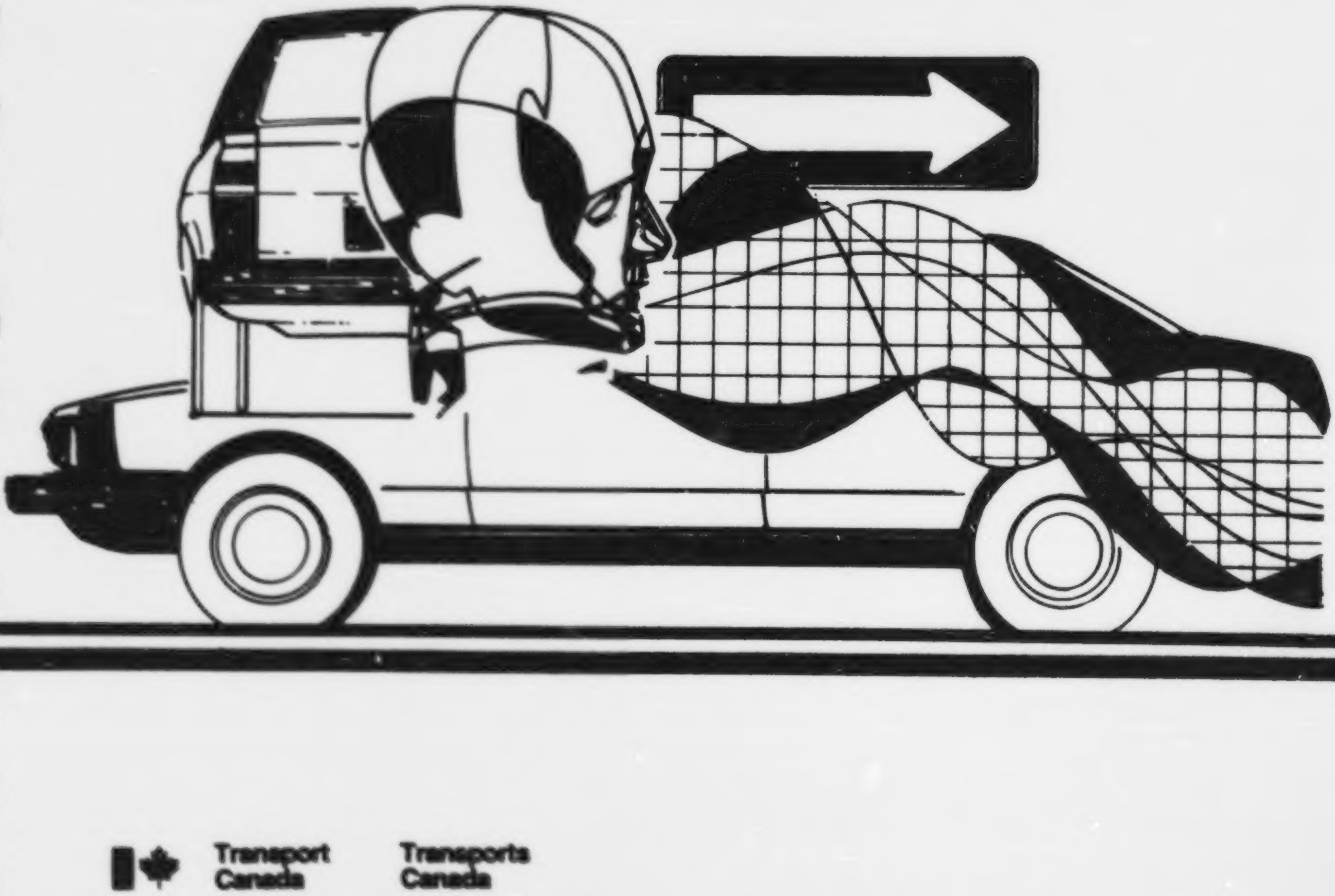
Volume

1

EVALUATION OF POTENTIAL IMPROVEMENTS IN AUTOMOBILE FUEL CONSUMPTION AT LOW TEMPERATURES - PHASE II

VOLUME 1 - MAIN BODY



Transport Canada   Transports Canada

Road Safety   Sécurité routière

TP 4077E

FINAL REPORT

EVALUATION OF POTENTIAL IMPROVEMENTS IN AUTOMOBILE FUEL CONSUMPTION AT LOW TEMPERATURES - PHASE II

VOLUME 1 - MAIN BODY

For:

TRANSPORT CANADA
OTTAWA, ONTARIO

By:

DAVIS ENGINEERING LIMITED
CONSULTING ENGINEERS
OTTAWA, CANADA

DSS FILE NO: 23SU.T8080-1-9016
DE FILE NO: C81-140

AUGUST 1982

TABLE OF CONTENTS

PAGE:

LIST OF TABLES vi

LIST OF FIGURES ix

ACKNOWLEDGEMENTS xxi

ABSTRACT xxii

1.0 INTRODUCTION 1

- 1.1 Background 1
- 1.2 Objectives 2
- 1.3 Scope 2
- 1.4 Report Layout 3

2.0 EQUIPMENT/INSTRUMENTATION /FACILITIES 4

- 2.1 Test Vehicles 4
- 2.2 Gravimetric Fuel Consumption Measurement System 4
- 2.3 Test Fuels Specifications 5
  - 2.3.1 Gasoline 5
  - 2.3.2 Propane 6
- 2.4 Test Facilities 6
  - 2.4.1 Large Environmental Chamber 6
  - 2.4.2 Clayton Model CTE 50 Dynamometer 6
  - 2.4.3 Low Speed Track 7
  - 2.4.4 Laboratory 7
- 2.5 Test Equipment/Instrumentation 7
  - 2.5.1 Digital Data Acquisition System 7
  - 2.5.2 Analog Data Acquisition 8
  - 2.5.3 Exhaust Emissions Sampling and Analysing System 8
  - 2.5.4 Miscellaneous Equipment/Instrumentation 8

TABLE OF CONTENTS (Cont'd)

PAGE:

3.0 TEST PROCEDURES 9

3.1 Driveability Test Procedure 9
3.2 Scheduled Vehicle Maintenance 10
3.3 Dynamometer Test Procedures 10
3.3.1 Dynamometer Calibration 10
3.3.1.1 Electrical Road Load Power Control Calibration 10
3.3.1.2 Mechanical Calibration 11
3.3.1.3 Torque/Horsepower Versus Speed Verification 12
3.3.1.4 Loaded Vehicle Coastdowns 12
3.3.2 Exhaust Emissions Sampling and Analysing System Calibration 12
3.3.2.1 Critical Flow Venturi (CFV) and Flow Computer Calibration 13
3.3.2.2 Gas Divider Calibration Check of Analysers 14
3.3.2.3 Critical Flow Orifice Check 14
3.3.2.4 NO_x Converter Efficiency Check 15
3.3.2.5 System Leak Check 15
3.3.3 Dynamometer Mechanical Warmup 15
3.3.4 Instrumentation Warmup and Preparation 15
3.3.5 Fuel Consumption & Emissions Test Methods 16
3.3.6 Laboratory Procedures 17
3.3.7 Dynamometer Test Run Validity Criteria 18

TABLE OF CONTENTS (Cont'd)

PAGE:

3.4 Fuel Consumption and Exhaust Emissions Calculation Procedure 18

3.5 Calculation of Repeatability 18

3.6 Data Acquisition and Reduction 19

- 3.6.1 Digital Data Acquisition & Reduction 19
- 3.6.2 Analog Data Acquisition & Reduction 20
- 3.6.3 Miscellaneous Data Acquisition and Reduction 21

3.7 Hardware Configurations Tested 21

- 3.7.1 Optimum Cold Timing Configuration (O.C.T.) 21
  - 3.7.1.1 Base Vehicle Description 22
  - 3.7.1.2 Optimum Cold Timing Hardware Description & System Operation 22
  - 3.7.1.3 Development of the Cold Spark Advance Curve 23
  - 3.7.1.4 Preliminary Testing 26
  - 3.7.1.5 Final Testing 27
- 3.7.2 Automatic Idle Speed (A.I.S.) Configuration 27
  - 3.7.2.1 Base Vehicle Description 27
  - 3.7.2.2 Automatic Idle Speed 28
  - 3.7.2.3 Preliminary Testing 30
  - 3.7.2.4 Final Testing 31
- 3.7.3 Propane Configuration 31
  - 3.7.3.1 Fuel Tank and Hardware 32
  - 3.7.3.2 Pressure Regulator and Vaporizer 32
  - 3.7.3.3 Vapour Carburetion (Mixer) 33
  - 3.7.3.4 Electronic Spark Advance (ESA) Unit 33
  - 3.7.3.5 Fast Idle System 33
  - 3.7.3.6 Air Cleaner Housing and Element 34
  - 3.7.3.7 Calibrations A and B 34
  - 3.7.3.8 Development 34
  - 3.7.3.9 Final Testing 35

TABLE OF CONTENTS (Cont'd)

PAGE:

4.0 RESULTS 36

4.1 Fuel Consumption 36
4.2 Exhaust Emissions 36
4.3 Temperature Traces 36
4.4 Analog Recorder Traces 37
4.5 Driveability Test Results 37

5.0 DISCUSSION OF RESULTS 38

5.1 Optimum Cold Timing Configuration 38
  5.1.1 Fuel Consumption Results 38
  5.1.2 Emissions Results 40
  5.1.3 Temperature Traces 41
  5.1.4 Driveability 41
5.2 Automatic Idle Speed Configuration 41
  5.2.1 Comparison of Fuel Consumption 41
  5.2.2 Emissions Results 43
  5.2.3 Temperature Traces 45
  5.2.4 Driveability 45
5.3 Propane Configuration 45
  5.3.1 Fuel Consumption Results 46
  5.3.2 Emissions Results 49
  5.3.3 Driveability 50
5.4 Propane Versus Gasoline Comparisons 51
  5.4.1 Fuel Consumption Comparison 51
  5.4.2 Emissions Comparison 53
5.5 Fuel Consumption Versus Temperature Comparison - All Vehicles 53
5.6 Problems Encountered and Solutions Implemented 54

TABLE OF CONTENTS (Cont'd)

PAGE:

6.0 CONCLUSIONS AND RECOMMENDATIONS 56

- 6.1 Conclusions 56
- 6.2 Recommendations for Future Work 58

REFERENCES 61

LIST OF TABLES

Table No.:	Description:	Page:
1	Test Vehicle Identification	62
2	Test Fuel Specifications (Leaded Gasoline)	63
3	Propane Test Fuel Analysis	64
4	Thermocouple Types and Location	65
5	Vehicle Parameter Sensors	66
6	Exhaust Emissions Bench Components	67-68
7	Equipment/Instrumentation	69-73
8	Dynamometer Road Load Power Settings for Different Test Temperatures	74
9	Heater Settings at Different Test Temperatures	75
10	Sample Printout of Data & Results	76-77
11	Summary of Parameters Plotted for Fuel Consumption Tests of the Optimum Cold Spark Timing Configuration (Vehicle 1)	78
12	Summary of Parameters Plotted for Fuel Consumption Tests of the Automatic Idle Speed Control Configuration (Vehicle 3)	79
13	Summary of Parameters Plotted for Fuel Consumption Tests of the Propane Configuration (Vehicle 9)	80
14	Watanabe Recorder Output & Scaling	81
15	Test Number Interpretation	82
16	Summary of Tests Performed on Vehicle 1 Optimum Cold Timing	83

LIST OF TABLES

Table No.:	Description:	Page:
17	Summary of Tests Performed on Vehicle 3 Automatic Idle Speed Control	84
18	Summary of Tests Performed on Vehicle 9 Propane Configuration	85
19	Vehicle 1 Optimum Cold Timing-Base Vehicle Specifications	86-88
20	Vehicle 1 Optimum Cold Timing-Modified Vehicle Specifications	89-91
21	Vehicle 3 Automatic Idle Speed-Base Vehicle Specifications	92-94
22	Vehicle 3 Automatic Idle Speed-Modified Vehicle Specifications	95-97
23	Vehicle 9 Propane-Calibration A and B Specifications	98-99
24	Average Fuel Consumption Data for Optimum Cold Timing Configuration (Vehicle 1)	100
25	Average Fuel Consumption Data for Automatic Idle Speed Configuration (Vehicle 3)	101
26	Average Fuel Consumption Data for Propane Configuration (Vehicle 9)	102
27	Average Exhaust Emissions Data for Optimum Cold Timing Configuration (Vehicle 1)	103
28	Average Exhaust Emissions Data for Automatic Idle Speed Control Configuration (Vehicle 3)	104
29	Average Exhaust Emissions Data for Propane Configuration (Vehicle 9)	105
30	Summary of Driveability SID Ratings	106
31	Average Fuel Consumption Data for Optimum Cold Timing Configuration (Vehicle 1) Preliminary Tests	107

LIST OF TABLES

Table No.:	Description:	Page:
32	Improvement in Fuel Consumption Over Baseline For Optimum Cold Timing Vehicle	108
33	Modified Versus Baseline Exhaust Emissions Comparison - Optimum Cold Timing Configuration (Vehicle 1)	109
34	Improvement in Fuel Consumption Over Baseline for Automatic Idle Speed Vehicle	110
35	Modified Versus Baseline Exhaust Emissions Comparison - Automatic Idle Speed Configuration (Vehicle 3)	111
36	Difference in Fuel Consumption of Calibration B Versus Calibration A for Propane Car (Vehicle 9)	112
37	Calibration B Versus Calibration A Exhaust Emissions Comparison - Propane Configuration (Vehicle 9)	113
38	Average Fuel Consumption Data from Carbon Balance Results - Vehicle 3 Base Configuration	114
39	Propane to Gasoline Fuel Consumption Comparison Vehicle 9 Calibration B Versus Vehicle 3 in Base Configuration	115
40	Increase in Fuel Consumption with Temperature for All Vehicles	116
41	Carbon Balance Versus Gravimetric Fuel Consumption Results Comparison Vehicle 3 Base Configuration	117

LIST OF FIGURES

Figure No.	Description	Page:
1	Gravimetric Fuel Consumption System	118
2	Exhaust Emissions Sampling System - Control Unit	119
3	Exhaust Emissions Sample Storage Bags	120
4	Exhaust Emissions Analysis Unit	121
5	Instrumentation - Datalogger, Computer and Storage System, and Video Display Terminal	122
6	Instrumentation - Watanabe Recorder, Fuel Pressure and Manifold Vacuum Indicators, and Control Panel	123
7	Instrumentation - Fuel Cannister and Weigh Scale	124
8	Instrumentation - Coastdown Timer and Relative Humidity Indicator	125
9	XY Plotter and Signal Controls	125
10	Instrumentation - Dynamometer Road Load Power Control	126
11	Theoretical Torque/Horsepower Versus Front Roll Speed Characteristics for Clayton CTE 50 Dynamometer	127
12	Vapour Canister Hose Routing	128
13	Digital Data Collection	129
14	Digital Data Reduction	130
15	Scaling on Watanabe Recorder	131
16	Startup Portion of Analog Recorder Output	132

LIST OF FIGURES

Figure No.	Description	Page:
17	Vehicle No. 1 - Base Configuration Spark Curve	133
18	Cold Transient Fuel Consumption Vs. Spark Advance for Constant Time Interval	134
19	Cold Transient Fuel Consumption Vs. Spark Advance for Constant Time Interval	135
20	Cold Transient Fuel Consumption Vs. Spark Advance for Constant Time Interval	136
21	Cold Transient Fuel Consumption Vs. Spark Advance for Constant Time Interval	137
22	Optimum Road Load S/A Vs. Engine Coolant Temperature at 1600 RPM	138
23	Optimum Road Load S/A Vs. Engine Coolant Temperature at 2000 RPM	139
24	Optimum Road Load S/A Vs. Engine Coolant Temperature at 2400 RPM	140
25	Optimum Road Load S/A Vs. Engine Coolant Temperature at 2800 RPM	141
26	Optimum Cold Timing - Calibration A	142
27	Optimum Cold Timing - Calibration B	143
28	Optimum Cold Timing - Calibration C	144
29	Vehicle No. 3 - Automatic Idle Speed Spark Curve "Base" PROM	145
30	Vehicle No. 3 - Automatic Idle Speed PROM "A"	146
31	Vehicle No. 3 - Automatic Idle Speed PROM "A-1" and A-1'	147
32	Vehicle No. 3 - Automatic Idle Speed PROM 'A-2'	148

LIST OF FIGURES

Figure No.	Description	Page:
33	Propane Fuel System	149
34	Propane Vehicle - Calibration A Schematic	150
35	Propane Vehicle - Calibration B Schematic	151
36	Vehicle No. 9 - Propane - PROM AP1	152
37	Vehicle No. 9 - Propane - PROM 2PB	153
38	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at +25 deg. C.	154
39	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at +25 deg. C.	155
40	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at +25 deg. C.	156
41	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at +25 deg. C.	157
42	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at +25 deg. C.	158
43	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at +25 deg. C.	159
44	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at +25 deg. C.	160
45	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at +25 deg. C.	161
46	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at 0 deg. C.	162

LIST OF FIGURES

Figure No.	Description	Page:
47	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at 0 deg. C.	163
48	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at 0 deg. C.	164
49	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at 0 deg. C.	165
50	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at 0 deg. C.	166
51	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at 0 deg. C.	167
52	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at 0 deg. C.	168
53	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at 0 deg. C.	169
54	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at -20 deg. C.	170
55	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at -20 deg. C.	171
56	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at -20 deg. C.	172
57	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at -20 deg. C.	173

LIST OF FIGURES

Figure No.	Description	Page:
58	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Temperature and Fuel Cons. Trace at -20 deg. C.	174
59	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at -20 deg. C.	175
60	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at -20 deg. C.	176
61	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Temperature and Fuel Cons. Trace at -20 deg. C.	177
62	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at +25 deg. C.	178
63	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at +25 deg. C.	179
64	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at +25 deg. C.	180
65	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at +25 deg. C.	181
66	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at +25 deg. C.	182
67	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at +25 deg. C.	183
68	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at +25 deg. C.	184

LIST OF FIGURES

Figure No.	Description	Page:
69	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at +25 deg. C.	185
70	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at 0 deg. C.	186
71	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at 0 deg. C.	187
72	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at 0 deg. C.	188
73	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at 0 deg. C.	189
74	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at 0 deg. C.	190
75	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at 0 deg. C.	191
76	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at 0 deg. C.	192
77	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at 0 deg. C.	193
78	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at -20 deg. C.	194
79	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at -20 deg. C.	195

LIST OF FIGURES

Figure No.	Description	Page:
80	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at -20 deg. C.	196
81	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at -20 deg. C.	197
82	Vehicle No. 3 - Automatic Idle Speed City Cycle Cold Transient Temperature and Fuel Cons. Trace at -20 deg. C.	198
83	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Temperature and Fuel Cons. Trace at -20 deg. C.	199
84	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Temperature and Fuel Cons. Trace at -20 deg. C.	200
85	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Temperature and Fuel Cons. Trace at -20 deg. C.	201
86	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at +25 deg.C.	202
87	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at +25 deg. C.	203
88	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at +25 deg. C.	204
89	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at +25 deg. C.	205
90	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at +25 deg.C.	206
91	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at +25 deg. C.	207

LIST OF FIGURES

Figure No.	Description	Page:
92	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at +25 deg. C.	208
93	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at +25 deg. C.	209
94	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at 0 deg.C.	210
95	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at 0 deg. C.	211
96	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at 0 deg. C.	212
97	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at 0 deg. C.	213
98	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at 0 deg.C.	214
99	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at 0 deg. C.	215
100	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at 0 deg. C.	216
101	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at 0 deg. C.	217
102	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at -20 deg.C.	218
103	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at -20 deg. C.	219
104	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at -20 deg. C.	220

LIST OF FIGURES

Figure No.	Description	Page:
105	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at -20 deg. C.	221
106	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at -20 deg.C.	222
107	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at -20 deg. C.	223
108	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at -20 deg. C.	224
109	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at -20 deg. C.	225
110	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at -20 deg.C.	226
111	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at -20 deg. C.	227
112	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at -20 deg. C.	228
113	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at -20 deg. C.	229
114	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at -20 deg.C.	230
115	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at -20 deg. C.	231
116	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at -20 deg. C.	232
117	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at -20 deg. C.	233
118	Vehicle No. 9 - Propane: City Cycle Cold Transient Temperature Trace at -35 deg.C.	234

LIST OF FIGURES

Figure No.	Description	Page:
119	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Temperature Trace at -35 deg. C.	235
120	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Temperature Trace at -35 deg. C.	236
121	Vehicle No. 9 - Propane: Highway Cycle Temperature Trace at -35 deg. C.	237
122	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Transient Parameter Comparison Trace	238
123	Vehicle No. 1 - Optimum Cold Timing: City Cycle Cold Stabilized Parameter Comparison Trace	239
124	Vehicle No. 1 - Optimum Cold Timing: City Cycle Soak and Hot Transient Parameter Comparison Trace	240
125	Vehicle No. 1 - Optimum Cold Timing: Highway Cycle Parameter Comparison Trace	241
126	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Transient Parameter Comparison Trace	242
127	Vehicle No. 3 - Automatic Idle Speed: City Cycle Cold Stabilized Parameter Comparison Trace	243
128	Vehicle No. 3 - Automatic Idle Speed: City Cycle Soak and Hot Transient Parameter Comparison Trace	244
129	Vehicle No. 3 - Automatic Idle Speed: Highway Cycle Parameter Comparison Trace	245
130	Vehicle No. 9 - Propane: City City Cold Transient Parameter Comparison Trace	246

LIST OF FIGURES

Figure No.	Description	Page:
131	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Parameter Comparison Trace	247
132	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Parameter Comparison Trace	248
133	Vehicle No. 9 - Propane: Highway Cycle Parameter Comparison Trace	249
134	Vehicle No. 9 - Propane: City City Cold Transient Parameter Comparison Trace	250
135	Vehicle No. 9 - Propane: City Cycle Cold Stabilized Parameter Comparison Trace	251
136	Vehicle No. 9 - Propane: City Cycle Soak and Hot Transient Parameter Comparison Trace	252
137	Vehicle No. 9 - Propane: Highway Cycle Parameter Comparison Trace	253
138	Vehicle No. 9 - Propane: Block Heater Warmup Temperature Trace at -20 deg. C.	254
139	Vehicle No. 9 - Propane: Block Heater Warmup Temperature Trace at -35 deg. C.	255
140	Per Cent Improvement in Fuel Consumption Over Base Vehicle for Optimum Cold Timing Configuration	256
141	Per Cent Improvement in Fuel Consumption Over Base Vehicle for Automatic Idle Speed Configuration	257
142	Fuel Consumption Vs. Test Temperature for Propane Vehicle - Calibrations A & B	258
143	City Cycle Exhaust Emissons Vs. Test Temperature for Propane Vehicle - Calibrations A & B	259

LIST OF FIGURES

Figure No.	Description	Page:
144	Energy Consumption Vs. Temperature for Base Gasoline Vehicle No. 3 and Propane Vehicle No. 9 (Calibration B)	260
145	Fuel Consumption Vs. Test Temperature for Base Gasoline Vehicles in Phase II - One Vehicle Only (No. 3)	261

ACKNOWLEDGEMENTS

DAVIS ENGINEERING LIMITED would like to acknowledge in particular the valuable assistance of **TRANSPORT CANADA** and **CHRYSLER CANADA** in all facets of the project including testing, interpretation of results, and preparation of the final report.

ABSTRACT

A two-phase test program was conducted to evaluate specific engine modifications for fuel consumption, exhaust emissions, and driveability at low ambient temperatures. In Phase 2, the following modifications were tested and compared with unmodified Omni/Horizon 1.7 litre cars:

- Optimum cold spark timing (OCT);
- Automatic idle speed control (AIS); and,
- Propane fuel system.

Fuel consumption and exhaust emission measurements were made at +25°C, 0°C, and -20°C using applicable Transport Canada Test Methods. The propane fuel car was also tested at -35°C. Driveability was evaluated using a Chrysler rating procedure.

The test results indicated significant fuel consumption improvements during engine warm-up at cold ambient temperatures for both gasoline engine modifications. Optimum cold spark timing increased hydrocarbon and oxides of nitrogen emissions during the cold transient portion of the city cycle at all temperatures, although the effect on overall city cycle emissions at +25°C was very small. Automatic idle speed substantially reduced hydrocarbon emissions during the city cycle at all temperatures but increased carbon monoxide emissions at +25°C.

The propane fuel car showed less fuel consumption degradation with cold temperatures than the gasoline cars. At all temperatures, it emitted lower hydrocarbons and carbon monoxide, but higher oxides of nitrogen, than the base gasoline car on the city cycle. All emissions measured were lower on the highway cycle.

Driveability was not significantly affected by any of the modifications, except that the propane vehicle displayed severe vaporization problems that prevented immediate drive away after a cold start at low temperatures. Use of a block heater prior to starting eliminated the problem.

1.0 INTRODUCTION

1.1 Background

An evaluation of potential improvements in automobile fuel consumption at low operating temperatures was proposed by Chrysler Canada Limited (UPC 328) and undertaken by Transport Canada. The testing program was carried out at the Transport Canada Motor Vehicle Test Centre in a two phased program, with contracts (OST80-00058 and 0SU81-00438) awarded to Davis Engineering Limited.

Phase 1 was conducted between October 1980 and April 1981 with three Omni/Horizon test cars incorporating the following modifications:

- early fuel evaporation;
- engine block heat conservation;
- high compression; and,
- engine block heater.

Comparative fuel consumption was evaluated at -20°C, 0°C and 25°C (-4°F, 32°F, and 77°F) using a cold room with a chassis dynamometer and following gravimetric measurement procedures from Transport Canada Test Methods for exhaust emissions and fuel consumption. Driveability was evaluated using a Chrysler rating procedure. A report on Phase 1 was completed in September 1981.

Phase 2 was conducted between October 1981 and May 1982 with three Omni Horizon test cars incorporating the following modifications:

- Optimum cold spark timing;
- Automatic idle speed control;
- Propane fuel system.

Comparative fuel consumption was measured as in Phase 1. For Phase 2 exhaust emissions were measured and the carbon balance method was used for fuel consumption measurement. The propane vehicle was also evaluated at -35°C (-31°F).

1.2 Objectives

The objective of Phase 2 was to assess cold weather fuel consumption, exhaust emissions and driveability performance of the modified vehicles compared with an unmodified Omni/Horizon.

1.3 Scope

Phase 2 included the developement of test instrumentation and test procedures for measuring fuel consumption by carbon balance, using an exhaust emission sampling and analysis method , as well as the gravimetric system from Phase 1.

A number of equipment and test procedure changes were also made to better simulate real life cold weather operation and to improve the quality of data. The most significant were:

- the digital data acquisition system was improved with respect to the storing of data and display;

- a high volume vehicle cooling fan was substituted for the standard fan used for emission testing;

- the heater/defroster controls were set to maintain comfortable passenger compartment temperatures. The controls were off for Phase 1; and,

- dynamometer road load power was adjusted for low temperature tests to reflect increased aerodynamic and rolling resistance effects during road driving in cold weather conditions.

1.4 Report Layout

Volume 1 contains the main body of the report including an equipment summary, test procedures, test results, discussion of results and conclusions. The appendices are in Volume 2. Referenced raw test data is on file with Transport Canada.

As identified in several sections of this report, the reader is referred to the Phase 1 Report for further clarification and details.

2.0 EQUIPMENT/INSTRUMENTATION/FACILITIES

2.1 Test Vehicles

The three test vehicles were 1980 Omni/Horizons with 1.7 litre four cylinder engines and three-speed automatic transmissions. Table 1 lists the vehicle number, vehicle identification number and configuration number for each vehicle.

All vehicles were tested at an inertia weight of 1,130 kg (2,500 lbs.). Road load power settings were dependent on test temperature as explained in Section 3.3.5.

2.2 Gravimetric Fuel Consumption Measurement System

The primary means of determining fuel consumption for the two gasoline cars was gravimetric. A fuel supply system was developed for Phase 1 testing to simulate the fuel supply characteristics of the cars. The system is illustrated in Figure 1 and briefly described as follows:

> The precision weigh scale measures the weight of the fuel consumed by the test vehicle. It is interfaced to the datalogger which provides a permanent record of the fuel consumption during the test. The fuel container rests on the weigh scale and is connected to the fuel supply and return lines via clear flexible tubing. These serve to isolate the fuel container from the rest of the system and provide a visual means of ensuring that all vapour and air bubbles are eliminated from the fuel lines during purging.

> A positive displacement fuel pump is used to supply fuel under pressure to the vehicle. Supply pressure at the carburetor is controlled by an in vehicle pressure regulator. Since reverse flow is not possible through the supply pump, a solenoid controlled bypass valve was installed in a loop circuit around the electric supply pump permitting the pressure to be bled off to zero when the test vehicle engine was turned off during the hot soak. An assortment of valves and quick disconnect couplings were installed on the vehicle in order to provide the necessary operating modes for the fuel supply system including operation of the OEM fuel system for tune-ups and track testing.

A complete description of the gravimetric fuel consumption system along with its operational modes was included in the Phase 1 report.

The gravimetric fuel measurement system was not used for the propane car. For this vehicle, fuel consumption figures were calculated from the emissions test results using carbon balance techniques.

2.3 Test Fuels Specifications

2.3.1 Gasoline

Regular leaded fuel from one batch stored in a 22 700 litre underground tank was used for all the gasoline vehicle tests. The fuel was analyzed by the Quality Engineering Test Establishment of the Department of National Defence with the results (Reference 1) summarized in Table 2.

2.3.2 Propane

The test fuel used for the Propane car was HD5. The fuel came from a common batch and was used for all testing at all temperatures, except for the initial comparison runs performed on the vehicle where the fuel was supplied by local retail outlets as required to fill the vehicle tank. A sample of the test fuel was submitted to Chrysler Canada Ltd. for analysis. The analysis specifications are summarized in Table 3.

2.4 Test Facilities

The testing was carried out at the Transport Canada Motor Vehicle Test Centre at Blainville, Quebec. The Centre is situated north of Montreal on 1,250 acres of Federal land. As in Phase 1, the following Test Centre facilities were used in this project.

2.4.1 Large Environmental Chamber

The large environmental test chamber has a floor area of 93 square meters and height of 6.4 meters. Its refrigeration system is capable of controlling the operating temperature to within 1.5°C of the set point between the range of -40°C to 0°C.

2.4.2 Clayton Model CTE 50 Dynamometer

The dynamometer is a standard emission water brake type consisting of four steel rolls with pneumatic roll air brakes and lift. It is mounted flush with the floor inside the environmental chamber. The system coolant consists of a water/glycol mixture to withstand the sub-zero temperatures. Roll bearings have been replaced with sealed bearings with low temperature grease. A power absorption unit connected directly to the front rolls along with inertia weights permits the simulation of loadings from 0-50 HP and 455 kg (1,000 lbs.) to 4,025 kg (8.875 lbs.).

2.4.3 Low Speed Track

The 7.3 m wide by 6.9 km long low speed track was used for driveability testing of the test vehicles in their reference and modified configurations.

2.4.4 Laboratory

The 4,700 square meter laboratory includes a machine shop for general repairs or fabrication of new specialized equipment and a vehicle preparation area including a vehicle hoist and vehicle storage area. The laboratory was used for the scheduled maintenance checks on each vehicle.

2.5 Test Equipment/Instrumentation

As in Phase 1, two types of data acquisition systems were employed in the instrumentation; a digital system which typically took readings every 30 seconds, and an analog system for continuous measurement of certain parameters.

The following is a description of each of the data acquisition systems and other instrumentation and test equipment used in the program.

2.5.1 Digital Data Acquisition System

The digital system included a Digitec Data Logger, interfaced to a Centronics Printer and a Digital LSI-11 digital computer with floppy disc drives. Data were recorded on floppy discs for future reference and plotting, and on paper for hard copy backup. Table 4 lists the thermocouples which were monitored along with the specific details. In addition fuel consumed, dynamometer roll revolutions, and relative humidity were monitored and recorded. The system included an "interrupt" capability for specific points of interest as at the start and end of specific portions of the test cycle in addition to taking readings every 30 seconds.

2.5.2 Analog Data Acquisition

In addition to the digital monitoring of parameters listed in Table 4 other test vehicle engine parameters were monitored on a continuous basis during dynamometer testing. A list of these parameters and associated sensors and instrumentation is given in Table 5. A six channel strip chart recorder was used to record the data.

2.5.3 Exhaust Emissions Sampling & Analysing System

A vehicle exhaust emissions sampling and analysis system was supplied by Analygas Systems Ltd. and used to measure vehicle exhaust emissions. The system was typical equipment used for exhaust emission certification purposes. Exhaust emission measurements were used to calculate fuel consumption using carbon balance techniques. Table 6 lists the individual components of the system and Figures 2 to 4 display various views of the system.

2.5.4 Miscellaneous Equipment/Instrumentation

Table 7 lists the remaining equipment and instrumentation used for testing, maintenance, calibration, and data reduction. Photographs of the general instrumentation layout are given in Figures 5 to 10.

3.0 TEST PROCEDURES

The testing procedures for Phase 2 were generally the same as for Phase 1. The following sections briefly describe the test procedures and elaborate where Phase 2 differs from Phase 1.

3.1 Driveability Test Procedure

Vehicle driveability evaluation testing was performed for all configurations on the low speed test track at the Transport Canada Motor Vehicle Test Centre using the Chrysler SID (Start, Idle, Drive) Vehicle Driveability Procedure.

Prior to testing, vehicles were first preconditioned for 16 to 32 km at 80 km/h and then soaked for 14 to 24 hours.

During the driveability testing, the vehicles were rated for starting ease, idle quality, driveability, and performance under the following conditions:

- cold start and warmup;
- vehicle fully warmed up;
- hot start; and,
- partial cool down.

The vehicles were rated using a numerical rating system and conditions rated on a scale of 1 to 9 (9 = best), as defined in Appendix 1.

3.2 Scheduled Vehicle Maintenance

Vehicle maintenance was performed on each of the test vehicles on a regular basis. Service procedures specific to this program were supplied by Chrysler Canada and are given in Appendix 2. Vehicle maintenance was recorded on the sheet form shown in Appendix 3.

A complete vehicle maintenance, including oil and filter change, spark plug replacement, and vehicle tune-up, was performed at each change in test temperature. Typically, this occured every three weeks to one month during the program. In addition, vehicle tune-up specifications were checked and adjusted whenever a vehicle was changed between base and modified configurations.

3.3 Dynamometer Test Procedures

3.3.1 Dynamometer Calibration

A dynamometer calibration consisting of an electrical road load power control (RLPC) calibration and a mechanical calibration was performed on a schedule based on daily quality control checks. These daily checks included torque/horsepower versus speed verification and loaded vehicle coastdowns.

3.3.1.1 Electrical Road Load Power Control Calibration

The electrical (RLPC) calibration comprised a complete factory calibration procedure as outlined in Appendix 4 or a basic calibration procedure as outlined in Appendix 5. The former consisted of a systematic check of the entire RLPC unit and was only necessary if the basic calibration procedure proved inadequate or a major system component such as a printed circuit board was changed. The basic calibration procedure, which is a condensed version of the factory procedure, was generally performed on a monthly basis at ambient temperatures between 20°C and 30°C. It consisted of the following major system checks:

- roll speed calibration;
- torque cell calibration;
- power scaling verification; and,
- deadband adjustment.

3.3.1.2 Mechanical Calibration

The mechanical calibration was performed to determine the accumulated frictional losses in the dynamometer/flywheel system, thus permitting the determination of the actual road load power. The procedure (see Appendix 6) involved measuring the time for the dynamometer rolls to coast down from 55 mph to 45 mph (88.51 km/h to 72.42 km/h) at indicated power (HP) settings of 6.0, 8.0, and 10.0 hp for the front roll. The actual road load power (HP) present at the dynamometer rolls was calculated from the kinetic energy dissipated by the dynamometer rotating components as follows:

$$HP_d = (1/2)(W/32.2)\,\frac{(V_1^{\,2} - V_2^{\,2})}{550\ \Delta t_{avg}}$$

For Front & Rear Rolls

where V_1, V_2 = vehicle speed (ft/sec)

W = inertia weight (lbs.)

t = time (sec.)

The frictional losses (HP) were then calculated from,

$$HP_f = HP_d - HP_I$$

Dynamometer frictional losses were calculated using this procedure generally on a monthly basis at ambient temperatures between 20°C and 30°C after the electrical RLPC calibration had been performed.

3.3.1.3 Torque/Horsepower Versus Speed Verification

As a final check on the electrical/mechanical operation of the system, torque versus front roll speed and horsepower versus front roll speed curves were plotted and compared with the theoretical curves. These plots (see Appendix 7 for procedure and Figure 11 for theoretical curves) were useful in verifying the following:

i) load cell calibration;
ii) horsepower scaling calibration;
iii) deadband adjustment;
iv) exponent verification;
v) front roll speed calibration;
vi) thumbwheel calibration; and,
vii) operation of load/unload valves.

This procedure was performed immediately after a dynamometer electrical calibration and on a daily basis prior to vehicle testing on the dynamometer.

3.3.1.4 Loaded Vehicle Coastdowns

Loaded vehicle coastdowns were performed after each test run as part of the normal test procedure described in Section 3.3.6.

3.3.2 Exhaust Emissions Sampling and Analysing System Calibration

The exhaust emissions sampling and analysing system was calibrated on a regular basis. The procedures consisted of the following system calibrations and checks:

i) critical flow venturi (CFV) and flow computer calibration;
ii) gas divider calibration check of the analysers;
iii) critical flow orifice check;
iv) NO_X converter efficiency check; and,
v) a system leak check.

3.3.2.1 Critical Flow Venturi (CFV) and Flow Computer Calibration

This calibration was performed prior to initial testing, and when the critical flow venturi was changed for a larger unit due to insufficient capacity at the low ambient temperatures. Sections 4.1 and 4.2 of Reference 2 outline the specific procedures. Calibration of the Critical Flow Venturi is based upon the flow equation for the gas metering concept:

$$Q_{STD} = \frac{C_1 \; P_1}{\sqrt{T_1}}$$

where:

Q_{STD} = gas volume flow rate (SCFM) through the CFV at standard conditions

C_1 = venturi calibration coefficient
P_1 = venturi inlet static pressure (mm Hg)
T_1 = venturi inlet temperature

Evaluation of C_1 requires a known volume flow rate and measurement of the venturi inlet conditions, P_1 and T_1. Then:

$$C_1 = \frac{Q_{cal}\sqrt{T_1}}{P_1}$$

where Q_{cal} = calibration flowrate at standard conditions

A laminar flow element is used to measure Q_{cal}.

Once the value of C_1 has been established, the flow computer can be calibrated. The procedure involves a comparison of the calculated volume and the indicated volume on the sample control unit display for a given time period.

3.3.2.2 Gas Divider Calibration Check of Analysers

The standard gas divider was used to check the accuracy and linearity of all of the gas analysers (HC, CO, CO_2, and NO_X). The gas divider permits the formation of a range of eight calibration gases from a single calibration gas by accurately blending with a balancing gas. All analyser ranges that were used during testing were checked, generally on a monthly basis. The operating procedure for the gas divider is outlined in Reference 3.

3.3.2.3 Critical Flow Orifice Check

The Critical Flow Orifice Kit was used to check the dilution rate accuracy of the Constant Volume Sampler and to check for vacuum leaks in the system. The procedure outlined in Reference 4 involved the injection of a known amount of propane into the exhaust plenum system and comparing the calculated dilution with that indicated by the hydrocarbon analyser. A discrepancy between the two values would indicate a problem which would be sourced and repaired prior to further testing. This check was generally performed whenever the cold room was at room temperature.

3.3.2.4 NO_X Converter Efficiency Check

A NO_X converter efficiency check was performed, generally on a bi-weekly basis to ensure that the instrument maintained a high efficiency level. The procedures are outlined in Reference 5.

3.3.2.5 System Leak Check

A system leak check was performed on a daily basis to ensure accuracy of the results. The procedures for the system leak checks are outlined in Reference 2.

3.3.3 Dynamometer Mechanical Warmup

Prior to vehicle testing the dynamometer was warmed up by using a slave vehicle driven at 80 km/h for 30 minutes with the dynamometer set at the test road load power and inertia weight settings. If the dynamometer had not been operated within the previous two hours at test temperatures of 20° C to 30° C, and one hour at test temperatures below 20° C, this warmup procedure was followed.

3.3.4 Instrumentation Warmup and Preparation

Prior to daily testing or calibration all instrumentation was turned on and allowed to warm up for at least one hour (two hours in the case of the hydrocarbon analyser unit). To minimize condensation during the first vehicle test run of the day the insulated flexible tubing joining the test vehicle tailpipe to the sampling equipment was also preheated by running the exhaust of the warmup vehicle through it.

3.3.5 Fuel Consumption & Emissions Test Methods

Fuel consumption and exhaust emissions tests were conducted on a chassis dynamometer in the low temperature environmental chamber. The gasoline fueled cars were tested in accordance with applicable Transport Canada Test Methods except as stated below, (References 6 and 7), with fuel consumption determined both gravimetrically and using carbon balance techniques. For the propane car, similar test methods were followed except that fuel consumption was determined using only carbon balance techniques and a propane conversion factor (Appendix 8) was applied. In addition, the following procedural differences from Phase 1 were implemented:

- higher dynamometer road load power settings were used for the lower temperature tests to reflect the increase in aerodynamic drag and rolling resistance which is present under actual on - road conditions at low temperatures. Table 8 illustrates the dynamometer power settings used and Appendix 9 their determination;

- the heater/defroster controls were set to maintain comfortable passenger compartment temperatures to more closely represent actual on-road use. The settings used for the different test temperatures are listed in Table 9. For Phase I the controls were in the "off" position.

- a 0.9 meter diameter, high volume cooling fan of 680 m^3/min capacity was used instead of the standard fan normally used for emissions testing. Tests done with a velocity meter indicated that this fan provided a more even velocity distribution across the front of the car than the standard cooling fan, thereby more closely approximating actual on-road conditions;

- "slave" evaporative emissions cannisters were used on the gasoline vehicles to collect the evaporated fuel from the vehicle during all soak periods (Figure 12). This was done to ensure that the vehicle cannister was always empty and therefore emissions were not affected by varying amounts of fuel in the vehicle cannister; and,

- tests were run with vehicle hoods closed.

3.3.6 Laboratory Procedures

Laboratory test procedures were developed to meet the requirement of the referenced Transport Canada Test Methods and the program objective. These procedures were designed in a step-by-step check off format detailed in Appendix 11. A complete fuel consumption and exhaust emissions test sequence consisted of the following elements:

- vehicle preconditioning;
- city cycle test;
- pre-highway cycle preconditioning; and,
- highway cycle test.

The Phase 2 sequence was similar to the Phase 1 sequence except that the post-highway cycle preconditioning was replaced by prehighway cycle preconditioning so that the vehicle was kept running and warm while the city cycle emissions were analysed and the sample bags purged. The requirements for preconditioning were met satisfactorily with the revised sequence.

The City and Highway driving schedules are included in Appendix 10.

3.3.7 Dynamometer Test Run Validity Criteria

A number of items which could affect fuel consumption, exhaust emissions and test-to-test repeatability were considered in the assessment of a test run. A copy of the test quality control sheet summarizing these items is contained in Appendix 12. The following criteria were used as a guide in determining the validity of a test run:

- drivers aid trace;
- vehicle operating parameters;
- cold room temperature;
- dynamometer roll revolutions;
- average quick coast down times; and,
- odometer reading.

3.4 Fuel Consumption & Exhaust Emissions Calculation Procedure

A computer program was utilized in calculating the vehicle fuel consumption and exhaust emissions. A copy of the computer program is included in Appendix 13 and a sample print out of the data and results in Table 10.

3.5 Calculation of Repeatability

Each test was repeated until two to four valid results were achieved except in the case of the vehicle at -35°C where only one run was performed. The number of runs performed depended on the fuel consumption repeatability that was attained. A coefficient of variation of 1.5% or less was aimed at, where

$$\text{Coefficient of Variation} = \frac{\text{Mean Fuel Consumption}}{\text{Standard Deviation}}$$

For gasoline fueled vehicles the coefficient of variation was based on gravimetric fuel consumption results and on carbon balance results for the propane vehicle.

3.6 Data Acquisition and Reduction

Data Acquisition was provided by two automatic recording systems and a variety of instrument displays for the various parameters.

3.6.1 Digital Data Acquisition & Reduction

The programable Digitec data logger provided the multiplexing of signals from the fuel cannister weight scale, dynamometer rear roll revolution counter, humidity analyser and all thermocouples.

As data was collected by the Digitec it was transmitted to the LSI-11 system for storage and to the Centronics printer for hardcopy backup. The LSI-11 system displayed the data and stored it on floppy disk in ASCII code with the same format that was printed. The data was broken into files by run number as part of the operating procedure. The LSI-11 terminal display was used to visually check that the in-coming data was accurate and that the Digitec was running properly. The floppies were transported to Ottawa for reduction and plotting.

Data from a representative run for each vehicle configuration and ambient test temperature was reduced into graphical form using a Calcomp plotter interfaced with a PDP11 micro computer. These plots traced temperature and/or fuel consumption histories throughout the test and can be broken down into the following categories:

- temperature and fuel consumption traces;
- temperature traces;
- parameter comparison traces; and,
- block heat warmup traces.

Tables 11 to 13 give a summary of the parameters and test runs which were plotted for each vehicle in each category. Figures 13 and 14 display the steps involved in the data collection and reduction.

3.6.2 Analog Data Acquisition & Reduction

As stated in section 2.5.2, the analog (Watanabe) recorder was used to provide a continuous record of six engine related parameters throughout the dynamometer testing. Output from the recorder was continuously monitored throughout the test to verify that the various engine parameters were within specification. Table 14 summarizes the recorder outputs and scales used for all tests and Figure 15 shows the scaling on a blank portion of strip chart recorder paper. For resolution purposes, the recorder was run at two different speeds during the test. During the initial cold start, the recorder was run at 600 mm/min and for all other portions at 75 mm/min. The following information was acquired from the recording trace for each run (see Figure 16):

- time to first fire;
- start time;
- cranking voltage;
- cranking speed; and,
- choke full off time (vehicles #1 and #3).

3.6.3 Miscellaneous Data Acquisition & Reduction

All other test parameters were manually recorded including exhaust emissions, dynamometer quick coastdown times, and barometric pressure. A computer program utilizing the LSI-11 computer was used to generate summaries of the test results.

3.7 Hardware Configurations Tested

The hardware details and operational descriptions of all of the test configurations, including the base vehicles, are given in this section. It should be noted that the two gasoline vehicles were substantially different in that the optimum cold timing vehicle had a 9.5:1 compression ratio engine whereas the automatic idle speed vehicle had a standard 8.2:1 compression ratio engine. The automatic idle speed vehicle in base configuration was used for comparison with the propane vehicle.

The test number interpretation scheme is given in Table 15. Tables 16 to 18 relate the test numbers to the hardware configurations and the type of tests performed for each of the vehicles.

3.7.1 Optimum Cold Timing Configuration (O.C.T.)

This configuration was designed to improve fuel consumption and driveability during the engine warmup period by optimizing spark advance for cold engine operation. A "cold" spark curve was developed separate to the standard "warm" spark curve by running engine dynamometer tests in a cold room, and by running on-road driveability tests on a 1.7 litre equipped vehicle. Back-to-back chassis dynamometer tests were then performed with and without the optimized cold spark timing to determine the benefits of optimum cold timing over conventional spark timing.

3.7.1.1 Base Vehicle Description

In order to determine the fuel consumption benefits of optimum cold timing the vehicle was tested in base and modified configurations. A high compression ratio (9.5:1) 1.7 litre vehicle with conventional spark timing was chosen as the base vehicle. This vehicle was chosen for testing of optimum cold timing since it was believed that the high compression ratio engine with its knock limited spark advance characteristics (i.e., the spark advance was limited to an advance that is less than optimum for fuel consumption, because of spark knock) was more representative of present and future engine designs than the standard 8.2:1 compression ratio engine. This was of importance to the development of optimum cold timing as will be described later.

Specifications for the base vehicle are given in Table 19 and Figure 17. The vehicle had accumulated approximately 24,000 km before the start of testing, 12,000 km of which were accumulated with the vehicle in the high compression configuration.

3.7.1.2 Optimum Cold Timing Hardware Description & System Operation

In order to permit the development of optimum cold spark timing on a vehicle without compromising the conventional or "warm" spark timing, two spark control computers were used, one for the cold spark timing and a second for the warm spark timing. The computers used were both Chrysler Model OEM computers modified with external PROM sockets for easy changing of the spark schedule. An electronic controller was used to switch from the "cold" computer to the "warm" computer based on engine coolant and intake charge temperatures.

If the engine coolant temperature was below 49°C and the intake charge temperature was below 17°C the engine would start and run on the cold computer. Once either the engine coolant or intake charge temperature reached the prescribed setting the controller would switch operation from the cold to the warm computer. Reversion back to the cold computer was not permitted unless the engine was shut off and both temperature conditions were met.

3.7.1.3 Development of the Cold Spark Advance Curve

The first phase of testing to develop a cold spark advance curve was performed by Chrysler Canada Limited and the National Research Council of Canada. Tests were performed on a 1.7 litre, 9:5:1 compression ratio engine mounted on an engine dynamometer in the National Research Council cold room, using premium leaded fuel.

A testing procedure was developed to determine the varying relationship between spark advance and fuel consumption for the engine as it warmed up from a cold start. This was done by performing a series of cold start runs on the engine at selected engine RPM and spark advance settings. For each RPM selected, cold start runs were made at spark advance settings of 10°, 20°, 30°, 40°, and 50° BTDC. Spark advance was held constant for each run and throttle opening was varied continually to maintain a constant torque output as the engine warmed up. By comparing the fuel consumption results of successive cold start runs made at different spark advance settings it was possible to determine the optimum spark advance for any RPM and engine temperature condition. The results are presented graphically in Figures 18 to 21 as lines of fuel consumption versus spark advance at RPM settings of 1600, 2000, 2400, and 2800.

These curves were then used to develop the graphs of optimum road load spark advance versus engine coolant temperature shown in Figures 22 to 25. Finally, based on these figures, a tentative cold spark advance schedule and a cold-to-warm spark timing switch point were chosen for the next phase of development.

It should be noted that the data and graphs presented to this point are for part throttle on road-load conditions only, and that no wide open throttle dynamometer work was performed on the cold engine.

The next phase of development was carried out by Chrysler Canada Limited in Windsor. Testing was transferred to a vehicle fitted with a similar high compression engine for on-road driveability testing. All on-road testing was performed using regular, leaded gasoline.

Determination of the part throttle or road-load spark timing was done using the tentative spark schedule developed earlier with some fine tuning done for optimum driveability. Since no wide open throttle cold start dyno work was performed, the governor or wide open throttle spark curve was developed primarily on the basis of maximum spark advance obtainable without spark knock. This was deemed to be a reasonable approach to take since this engine was knock limited at wide open throttle when fully warmed up (i.e., when fully warmed up the engine is operating with a spark advance schedule that is retarded from optimum in order to avoid spark knock). It was therefore possible to improve power and efficiency on the cold engine by advancing the spark to a new knock limited spark advance setting. It was found however, that even with a very cold engine, the cold engine knock limited spark advance was only about 4° more advanced than when fully warmed up. The resultant cold spark advance curve (Calibration A) is shown in Figure 26.

Once a single cold spark calibration was determined, two simplified calibrations were developed (Calibrations B and C, Figures 27 and 28), to determine the simplest optimum cold calibration which would give the desired results. Calibration B was developed from Calbration A by removing the dip in the vacuum advance curve that occurred at approximately 2000 RPM. This dip in the vacuum advance curve was thought to be a characteristic of the individual engine tested and not of all 1.7 litre engines. Calibration C was a further simplification of the original cold calibration. It was simplified to the point where the cold curve was developed by adding 4° of advance to the basic timing setting of the warm curve and limiting the total spark advance (basic + governor + vacuum) to a maximum of 45° BTDC. Although quite different from the original curve, it was believed that this latter curve would provide most of the benefits of the original curve in a form that could be more easily implemented in a conventional or production electronic spark advance system.

At this point a few special features of the cold spark advance curve can be noted. First, since the cold curve had significantly greater spark advance off-idle than the previous production type spark curve, fast idle engine speeds increased sigificantly during cold engine operation. The fast idle setting was therefore re-adjusted downward to compensate for this increased speed (with obvious fuel consumption benefits). This readjustment created a minor problem in that the engine, when cold, maintained a high idle speed largely as a result of an advanced spark setting and not a high throttle opening. When the automatic transmission was put into gear after a cold start, the engine would loose both speed and manifold vacuum very quickly. If the engine had not been running long enough the loss in engine speed would be enough to cause a significant loss in vacuum spark advance, further reducing idle speed and manifold vacuum. This quite often ended in a die-out. This problem was solved by providing an additional spark advance function in the shape of a ramp (see Start Transient Ramp in Figures 26, 27, and 28) for a short period of time after a cold start. If, after a cold start, the engine speed dropped too low, the ramp function would add spark advance thereby maintaining a fast idle setting. This function virtually eliminated the die-out problem.

Finally, it should be noted that the clock function (see Table 19 for description of how the clock function works) of the Electronic Spark Advance unit, normally used on production vehicles to control HC and NO_X emissions by retarding the spark advance, was not used on this vehicle during the testing program. This function was eliminated because the prototype electronic control unit used to switch from the cold to warm computer interfered with the operation of the clock. Elimination of the clock function, although increasing HC and NO_X emissions, did not affect the comparison of base to modified configurations, since all tests were run without the clock function.

Complete specifications of the vehicle in the modified configuration are shown in Table 20.

3.7.1.4 Preliminary Testing

At this point, testing was transferred from Chrysler Canada to the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec for testing in the cold room.

In order to select the best cold spark advance calibration, preliminary comparison tests were run at -20°C. Calibrations A, B, and C were compared for fuel consumption by running two city and highway cycle tests for each calibration, and the best calibration was selected for final testing.

3.7.1.5 Final Testing

Once the optimum calibration had been determined and selected, tests were run at -20°C, 0°C and +25°C on the base and modified vehicle.

3.7.2 Automatic Idle Speed (A.I.S) Configuration

This configuration was designed to improve fuel consumption and driveability by improving idle speed control during the engine warmup period. The warmup idle speed schedule and cold spark schedule was determined by on-road driveability testing of this vehicle with the automatic idle speed hardware installed prior to cold room testing at the Motor Vehicle Test Centre. Preliminary chassis dynamometer testing was performed at the Motor Vehicle Test Centre to improve the warmup schedule derived during on-road testing.

The automatic idle speed system also controlled idle speed after warmup, however, the primary objective of this package was to investigate fuel consumption improvement during engine warmup.

3.7.2.1 Base Vehicle Description

Vehicle Number 3 was tested in its base configuration in order to establish a baseline for configuration comparisons. The test vehicle was a 1980 Dodge Omni/Plymouth Horizon model utilizing 1979 carburetion, spark timing and exhaust gas recirculation. A 1982 distributor and prototype Electronic Spark Advance (ESA) unit were used to allow operation with automatic idle speed when the car was converted to the modified configuration. Specifications for the base vehicle are given in Table 21 and the spark advance curve is shown in Figure 29. This vehicle had accumulated 20,000 km before the start of testing.

3.7.2.2 Automatic Idle Speed

With this configuration, changes were made to the carburetor and spark schedule to lower the idle speed and improve driveability during engine warmup. These changes included:

- changing the anti-dieseling solenoid which performs the function of a throttle stop in the base car to a linear action throttle actuator motor.
- changing the carburetor three step fast idle cam to a single step fast idle cam; and,
- installation of a prototype electronic spark advance unit and sensors to control the throttle actuator motor.

3.7.2.2.1 Summary of Automatic Idle Speed Control

The automatic idle speed control system was designed to improve fuel consumption and idle quality. The engine idle speed was regulated by coolant temperature and gear selector position. As coolant temperature increased, the engine speed was reduced in a linear relation as shown in Table 22 and Figures 30, 31, and 32. Above a prescribed coolant temperature, idle speed was controlled to one of two speeds dependent on whether the vehicle was in neutral or drive.

Driveability was aided by an inverted vacuum spark curve during engine warmup. The cold vacuum spark timing advanced the spark with decreasing manifold vacuum, as shown in the same figures. This acted to stabilize idle speeds by adding spark advance if engine idle speeds and manifold vacuum dropped faster than the throttle actuator could respond.

Control during and after engine deceleration was accomplished by a programmed deceleration control speed, and a throttle kick function. Control of the idle speed was resumed on a deceleration only after the idle contact switch was closed and engine speed fell below the deceleration control speed. The throttle kick function held the throttle open a prescribed amount for a fixed period of time on deceleration. These two functions, used together, provided a controlled engine deceleration rate and stable idle speed after deceleration.

3.7.2.2.2 Throttle Actuator Motor

The throttle actuator motor was mounted in place of the standard anti-dieseling solenoid. This linear action motor controls the closed throttle position by providing a moveable throttle stop for the existing throttle lever. The unit contains a pressure sensitive switch which signals the computer when the throttle is closed.

3.7.2.2.3 Fast Idle Cam

The original three step cam which controls engine idle speed during warmup as the choke comes off was replaced by a single step cam. The single high step allows for sufficient throttle opening during cold start, choke on conditions when the throttle actuator motor is beyond its limits of travel. The other cam steps were unnecessary since the throttle actuator motor controlled engine idle speed once the engine was running and the large throttle opening was not needed.

3.7.2.2.4 Electronic Spark Advance Unit (ESA)

The original electronic spark advance unit was replaced with a prototype unit incorporating control logic for both spark advance and idle speed control. The unit was fitted with an external PROM socket for easy changing of the PROMS containing the spark advance and idle speed constants. The original coolant temperature switch was replaced with a thermistor type sensor which provided an analog signal to the electronic spark advance unit. A gear selector sensor was also incorporated in the control system to allow neutral and drive idle speeds to be determined independently.

In order to facilitate engine tune-ups with the automatic idle speed system installed, a special service PROM was used (see Appendices 2 and 14).

3.7.2.3 Preliminary Testing

Preliminary tests were carried out on the vehicle to evaluate the initial automatic idle speed calibration and improve upon it where necessary. Two problem areas were encountered. First, the engine sometimes would stall out shortly after a cold start. This was the result of an over-advanced cold vacuum spark curve as well as a too low cold idle speed. Although the cold spark curve was designed to help prevent engine stallouts by advancing the spark as engine manifold vacuum dropped, it was determined that the spark schedule was actually over-advancing the spark and therefore having the opposite effect. The problem was corrected by limiting the maximum available cold vacuum advance from 20° to 15° and increasing the cold engine idle speed from 1100 to 1200 RPM, as shown in Figure 31 and Table 22.

The second problem appeared in the deceleration programming of the system. After a deceleration the engine would sometimes undershoot the programmed idle speed before reaching steady state operation. This was corrected by lowering the deceleration control speed below the throttle kick RPM. (See Table 22, PROM A-1'.) This held the throttle open slightly on deceleration and provided a stable transition from deceleration to curb idle control under all operating conditions.

A final round of testing and fine-tuning produced the calibration shown in Figure 32 and Table 22 as PROM A-2.

3.7.2.4 Final Testing

Once the optimum calibration had been determined and selected, tests were run at -20°C, 0°C, and +25°C on the base and modified vehicles.

3.7.3 Propane Configuration

Vehicle number 9 was not tested in a base gasoline calibration, as vehicles number 1 and 3, but in two propane calibrations. The test vehicle was a 1980 Dodge Omni/Plymouth Horizon model with 1982 distributor and electronic spark advance (ESA) unit. The engine had accummulated 10,000 km in its high compression (9.3:1) form on gasoline before propane conversion and approximately 3,000 km on propane before the start of this phase of the program. The specifications for the propane vehicle are shown in Table 23.

Changes made to the vehicle to convert it to propane included the installation of: (see Figure 33):

- a pressure vessel fuel tank and related hardware;
- a fuel pressure regulator and vaporizer;
- a vapour mixer/carburetor;
- an electronic spark advance unit with an external PROM socket;
- an electric solenoid operated fast idle system; and,
- a higher volume air cleaner and housing.

The propane vehicle emissions system differed from its gasoline counterparts in that the air pump and EGR were removed to take advantage of the lower inherent emissions of an engine running on propane fuel. Since propane enters the intake manifold as a vapour, and therefore manifold heating is undesirable,the heat transfer from the exhaust manifold was minimized by a deflector.

3.7.3.1 Fuel Tank and Hardware

The fuel tank used was an ASME approved pressure vessel of 59 litre (13 gallons) capacity suitable for propane use and equipped with a fill valve, excess pressure relief valve, and excess flow check valve. The tank was also equipped with a float type fuel gauge and an 80% fixed liquid level gauge for fueling. The fuel line was fitted with a hydrostatic relief valve and protected from exhaust heat with shields at appropriate locations. A fuel filter-lockoff operated by engine vacuum, located in the engine compartment, was used to shut off fuel flow to the regulator/vaporizer when the engine was not running.

3.7.3.2 Pressure Regulator and Vaporizer

High pressure liquid propane enters the regulator after the filter-lockoff and is vaporized when the pressure is reduced to

10.3 kPa (gauge) (1.5 psig). The heat for vaporization is supplied by the engine coolant. The pressure is reduced further in a secondary chamber to -0.37 kPa (gauge) (-1.5 inch) of H_2O, referenced to the carburetor inlet air pressure, and maintained at this setting during changes in engine air flow requirements.

The secondary chamber is equipped with an electrically operated start assist valve (primer) which bleeds vapour to the carburetor throttle body during cranking for an enriched mixture.

3.7.3.3 Vapour Carburetion (Mixer)

The mixer consists of a pressure differential operated diaphram which controls a propane metering needle and is mounted on a conventional gasoline type one-barrel throttle body. As the air flow through the carburetor rises with engine demand the pressure differential increases between the incoming air above the mixer and the throttle body throat (above the throttle blade). The pressure differential proportionally raises the needle off of its seat and the flow of propane increases as determined by the needle contour. A restrictor in the fuel inlet regulates the amount of propane at high air flow during heavy loads and high engine speed operation.

3.7.3.4 Electronic Spark Advance (ESA) Unit

A programmable electronic spark advance unit was used to facilitate development of the propane spark curve.

3.7.3.5 Fast Idle System

A fast idle system was incorporated to overcome cold engine friction. The anti-dieseling solenoid as used on the gasoline carburetor was utilized as a fast idle solenoid. A relay circuit grounded to a coolant switch on the thermostat housing was used to activate the solenoid. A 66°C (150°F) switch point was chosen as the best compromise between engine idle speed and idle quality during warmup.

3.7.3.6 Air Cleaner Housing and Element

To accommodate the carburetor and to minimize the intake air restriction, the air cleaner and housing from the current Chrysler 2.2 litre engine were used. The housing was mounted to the left rear of the engine as the original 1.7 litre housing is mounted and was connected to the standard fresh air duct. Since the propane enters the engine as a vapour, the hot air stove used on the gasoline vehicle to preheat the incoming air was not used, except for one run at -20°C.

3.7.3.7 Calibrations A and B

The difference between the two propane configurations was in the vaporizor coolant circuit. Calibration A had the vaporizer coolant flow parallel to the bypass circuit. The bypass was restricted to maintain the same volume of coolant circulation as the standard gasoline engine. Calibration B had the vaporizer in series with the heater outlet and an unrestricted bypass circuit. Schematic diagrams of the vaporizer coolant circuit for the two calibrations are shown in Figure 34 and 35. It was believed that the two configurations would provide different warmup rates or steady state operating temperatures for the vaporizer, thereby affecting driveability and/or fuel consumption.

3.7.3.8 Development

During the trials period at the start of the program, testing at -20°C indicated that several areas of improvement were necessary.

Heat from the coolant is necessary to vaporize the propane, but after the initial start at -20°C it was found that the heat available from the coolant was not sufficient to vaporize the fuel required to meet the driving schedule. At this point the engine would die out from an apparent overlean condition caused by the inability of the vaporizer to vaporize sufficient fuel.

In order for the vehicle to meet the driving cycle at -20°C, it was necessary to implement a 2 minute idle warmup to ensure adequate heat for fuel vaporization.

The hot fast idle speed was revised from 1400 rpm to 1700 rpm as it was found that the idle speed in drive was not adequate to keep the engine running during the first minute of warmup.

Two spark schedules, (see Figures 36 and 37), were tested during the trial period, both with a vacuum advance cancell feature at idle. To improve idle fuel consumption, idle vacuum advance was used for all further testing. Since the emissions and fuel consumption were comparable between the two spark schedules, the schedule with constant spark advance over a wide range of manifold vacuum was used to ensure good idle quality under varying manifold vacuum conditions (PROM AP1, Figure 36).

3.7.3.9 Final Testing

Once the optimized spark schedule had been determined and selected, tests were run at -35°C for Calibration A and at -20°C, 0°C and +25°C for Calibrations A and B.

Calibration A was used for additional tests at -20°C to evaluate the influence of a block heater and a heated air intake system on fuel consumption and driveability.

4.0 RESULTS

This section summarizes the results of the tests performed in the program. Fuel consumption and exhaust emissions data for the various configurations and test temperatures are detailed in tabular and/or graphical form. A summary of the various engine temperatures recorded during the fuel consumption tests are presented in graphical form. In addition, temperature traces detailing engine block heater warmup characteristics are included.

4.1 Fuel Consumption

Tables 24 to 26 detail the average fuel consumption data for each vehicle configuration and test temperature investigated. The data have units of litres per 100 km and are the average of two tests except as noted. (See Section 3.3.6.)

4.2 Exhaust Emissions

Tables 27 to 29 detail the average exhaust emissions for each vehicle configuration and test temperature investigated. The data have units of grams/mile and represent an average of two runs except as noted.

4.3 Temperature Traces

Temperature traces from the fuel consumption tests, as described in section 3.6.1 are contained in Figures 38 to 139. Figures 38 and 122 illustrate the two plotting styles used for the traces. Figure 38 illustrates all of the data from one test run (temperatures and fuel consumed), all plotted on one graph. Figure 122 represents a comparison plot in which all like channels from each run are plotted on one graph. The temperature traces from the individual fuel consumption tests are contained in Figures 38 to 121 and from the comparison plots in Figures 122 to 137.

Traces from the block heater warmup are contained in Figures 138 and 139.

4.4 Analog Recorder Traces

Analog recorder traces of various engine related data (Table 4), as described in section 3.6.2 for each fuel consumption test are stored on file at Transport Canada.

4.5 Driveability Test Results

Driveability test results, as described in section 3.1 are stored on file at Transport Canada. Table 30 summarizes the driveability ratings for all three vehicles.

5.0 DISCUSSION OF RESULTS

5.1 Optimum Cold Timing Configuration

This vehicle underwent preliminary testing in the modified configuration at -20° C utilizing three spark curve calibrations which were designated A, B, and C. The test results for these are shown in Table 31. Based on the Bag 1 fuel consumption results, calibration C was chosen as the best calibration. The vehicle was then tested at +25°C, 0°C, and -20°C in the base and modified (calibration C) configurations. Due to the nature of this modification, Bag 1 of the city cycle was used as the primary basis of comparison between the base and modified vehicle. This was because switching from the cold to the warm spark curve generally occurred at or near the end of the second "hill" of Bag 1. At -20° C optimum cold timing also affected the Bag 3 results as described in the following section.

5.1.1 Fuel Consumption Results

The per cent improvement in fuel consumption over the base car is summarized in Table 32 for Bags 1, 2, and 3 of the city cycle, the composite city cycle, and the highway cycle. This relationship is also shown graphically in Figure 140.

Referring to the +25°C test results, fuel consumption in Bag 1 was reduced by 4.8% with the optimum cold timing configuration. This improvement in Bag 1 fuel consumption may at first seem improbable in that the cold spark advance curve only comes into effect if intake charge temperatures are below 17°C, yet the test was conducted at +25°C. This can be explained by the following. First, the base configuration utilizes a coolant switch to cancel all vacuum advance at engine coolant temperatures up to 66°C, whereas the car in the modified configuration does not utilize a coolant switch function. Therefore, even though the modified car is not operating on the low temperature spark curve at +25°C, it is operating with a more advanced spark (with vacuum advance) than the base car for the first few minutes of Bag 1. Second, as discussed in Section 3.7.1.3 the utilization of vacuum advance during warm-up allowed a lower fast idle speed setting further reducing fuel consumption.

Fuel consumption changed only slightly in Bags 2 and 3, increasing by 1.4% in Bag 2 and decreasing by 1.3% in Bag 3. Overall, composite city cycle fuel consumption decreased by 0.7% at the +25°C test temperature.

At 0°C, fuel consumption decreased by 4% in Bag 1 while remaining essentially unchanged for Bags 2 and 3 of the city cycle. Overall, the city cycle fuel consumption improved 1.4% with optimum cold timing.

At -20°C, fuel consumption decreased by 2.3% in Bag 1, increased by 0.6% in Bag 2 and decreased by 5.8% in Bag 3. The improvement in fuel consumption in Bag 1 was somewhat less than one would expect taking into account the improvements shown in Bag 1 of the tests at +25°C and 0°C, as well as the 5% improvement shown in Bag 3 of these tests (explained below). Why the improvement in Bag 1 fuel consumption was less at -20°C than at +25°C and 0°C is unknown.

The Bag 3 improvement at -20 °C is related primarily to the choke coming back on during the 10 minute soak period between Bags 2 and 3. (This occurs only at the -20°C test temperature.) Since the optimum cold timing configuration had an improved fast idle calibration, as discussed earlier, a fuel consumption improvement was obtained during the Bag 3 restart when the choke was on. Overall, composite city cycle fuel consumption was decreased by 1.7% at -20°C.

Highway cycle fuel consumption remained essentially unchanged from base to modified at all the test temperatures as expected.

5.1.2 Emissions Results

The percent change in exhaust emissions over the base car is summarized in Table 33 for Bags 1, 2 and 3 of the city cycle, the composite city cycle and the highway cycle. The most significant changes in exhaust emission with optimum cold timing occurred with HC and NO_X emissions in Bag 1 of the city cycle. Compared to the base car, HC emissions increased 18% at +25°C, 30% at 0°C and 35% at -20°C. An increase in HC emissions of 12% also occurred in Bag 3 of the -20°C tests. Overall, HC emissions for the composite city cycle increased by 2.9% at +25°C, 7.4% at 0°C, and 19% at -20°C.

Increases in NO_X emissions in Bag 1 varied from a 0.8% increase at +25°C to a 46% increase at -20°C. Overall, city cycle NO_X emissions increased by 1.5% at +25°C, -0.5% at 0°C and 5.7% at -20°C.

The changes noted in HC and NO_X emissions with optimum cold timing were not unexpected since advancing the spark normally increases both of these emissions.

Changes in CO emissions from base to modified configuration were not consistent and were believed to be small enough to be caused by test to test variations.

5.1.3 Temperature Traces

A comparison of thermostat termperatures for the base and modified vehicle indicates that optimum cold timing had virtually no effect on engine warm-up rate (see Figure 122). Other engine and vehicle related temperatures were also unaffected by optimum cold timing (see Figures 54 and 58).

5.1.4 Driveability

Referring to Table 30, cold driveability improved slightly with optimum cold timing. Cold idle quality appeared unchanged, but driveability improved slightly during vehicle accelerations after the cold start.

5.2 Automatic Idle Speed Configuration

This vehicle underwent preliminary testing in the modified configuration at -20°C utilizing various spark calibrations in order to optimize cold engine performance. Once an optimized calibration had been determined (PROM A-2), the vehicle was tested in the base and modified configurations.

5.2.1 Comparison of Fuel Consumption

The percent improvement in fuel consumption over the base car is summarized in Table 34, and shown graphically in Figure 141. These include Bags 1, 2 and 3 of the city cycle, and the composite city cycle and the highway cycle.

Referring to the +25°C test results, Bag 1 fuel consumption improved by less than 1% for the automatic idle speed configuration compared to the base vehicle. Fuel consumption was virtually unchanged by the automatic idle speed system due to the similar fast idle speeds during the first few minutes of operation. In the base configuration the fast idle speed, determined by the fast idle cam during choke on time, very nearly matched the idle speed determined by coolant temperature during warmup in the automatic idle speed configuration.

Bag 2 fuel consumption shows a 2.0% penalty in the automatic idle speed configuration. It appears that since the throttle was held open slightly during deceleration, as explained in section 3.7.2.3, an increase in fuel consumption resulted.

Bag 3 showed a slight penalty (0.8%) in the automatic idle speed configuration as a result of the deceleration control as explained for Bag 2. This was not as high a penalty as for Bag 2, probably because Bag 3 has fewer decelerations per unit of time than Bag 2, (see Appendix 10). Overall, city cycle fuel consumption increased 1.1% at the +25°C test temperature. Highway fuel consumption was essentially the same for both configurations and at all test temperatures as the automatic idle speed system had no effect on warmed up off idle operation.

The test results at 0°C indicate a reduction in Bag 1 fuel consumption of 1.9% for the automatic idle speed configuration. This is a result of a lower idle speed than the base configuration during the first few minutes of operation. Under these driving conditions the engine coolant temperature reaches a fully warmed up condition before the choke and fast idle cam are completely off, and the automatic idle speed hardware is therefore able to provide lower idle speed control during warmup than provided by the choke fast idle cam.

Bags 2 and 3 show fuel consumption penalties of 4.5% and 1.2% respectively in the automatic idle system configuration. This is a result of the throttle position during deceleration as previously explained in the +25°C tests. Overall, city cycle fuel consumption increased 1.9% at the 0° test temperature.

The test results at -20°C for Bag 1 fuel consumption showed a 12% improvement in the automatic idle speed configuration. This was due to a lower idle speed than the base configuration during warmup. In the base configuration the time to come off of the choke fast idle cam was approximately 9 minutes and resulted in a fast idle throughout Bag 1 and into Bag 2. In the automatic idle speed configuration the minimum idle speed was reached by the end of hill number 2 of Bag 1 at approximately 5 minutes.

Bag 2 shows a fuel consumption penalty of 3.2% in the automatic idle speed configuration. This is a result of the throttle position during deceleration as previously explained. Bag 3 fuel consumption showed a 3.3% improvement in the automatic idle speed configuration due to a lower initial idle speed. During the 10 minute hot soak the choke came back on as it cooled down. In the base configuration the choke fast idle cam, which is directly linked to the choke, caused a higher idle speed for the first few minutes of Bag 3 until the choke came off. In the automatic idle speed configuration the idle speed was controlled to the fully warmed up curb idle speed at coolant temperatures above 66°C and since the engine had only cooled down to approximately 82°C by the end of the hot soak, the engine speed returned to curb idle after start-up. Overall, city cycle fuel consumption decreased 3.3% at the -20°C test temperature.

5.2.2 Emissions Results

The percent change in exhaust emissions over the base car is summarized in Table 35 for Bags 1, 2 and 3 of the city cycle, the composite city cycle and the highway cycle.

The most significant changes in emissions with automatic idle speed hardware occurred during Bag 1 of the city cycle at all test temperatures. Highway emissions were essentially the same for both configurations for all test temperatures, as the automatic idle speed system had no effect on warmed up off idle operation.

Compared to the base configuration, Bag 1 HC emissions decreased 75% at +25°C, 27% at 0°C and 55% at -20°C. As one base run at +25°C had an abnormally long crank time of 13 seconds, the HC emissions decrease is distorted in favour of the automatic idle system configuration. No obvious reason was found for this long crank time. If this run is omitted from the results, then based on the other run at +25°C, HC emissions in the automatic idle speed configuration decreased by 32% in Bag 1. HC emissions in Bag 2 and 3 did not vary more than 12% between the two configuration at any test temperature. Overall, HC emissions for the city cycle decreased by 19% at +25°C, 14% at 0°C and 38% at -20°C. (Omitting the one run with the long crank time.)

CO emissions decreased in Bag 1 at all test temperatures but increased significantly in Bag 2 and 3 at +25°C and 0°C, apparently as a result of the throttle position during deceleration. Bag 1 CO emissions decreased 2% at +25°C, 11% at 0°C and 17% at -20°C in the automatic idle speed configuration due to the generally lower fast idle speed with automatic idle speed. Bag 2 and 3 CO emissions increased by 99% and 49% at +25°C and 41% and 50% at 0°C respectively. At -20°C CO emissions decreased 3% for Bag 2 and 13% for Bag 3, probably due to the lower fast idle speeds at this temperature with automatic idle speed. Overall, CO emissions for the city cycle increased by 41% at 25°C and 9.5% at 0°C, and decreased by 13% at -20°C.

NO_x emissions appeared to be inversely related to fuel consumption throughout city cycle. Where the automatic idle speed configuration showed decreased fuel consumption, the NO_x emissions increased. Bag 1 NO_x emissions increased 9.4% at 25°C, 4.2% at 0°C, and 47% at -20°C. Bag 2 NO_x emissions decreased 5.6% at 25°C, 13% at 0%, and 5.4% at -20°C. Bag 3 showed an increase of 20% at -20°C while decreasing 1.2% at 25°C and 7.0% at 0°C. Overall, NO_x emissions for the composite city cycle decreased 1.3% at 25°C and 7.2% at 0°C, but increased 11% at -20°C.

5.2.3 Temperature Traces

Referring to Figure 126, automatic idle speed appeared to have no effect on engine coolant warmup rate at +25°C and 0°C. However, automatic idle speed appears to have had some effect on warmup rate at -20°C, by lenghtening the warmup time somewhat.

Temperature data at -20°C for the automatic idle speed configuration, Figure 82, shows that all engine related temperatures were approximately 3°C lower than for the base configuration, Figure 78, at the end of Bag 1. This difference in warmup is a result of less heat rejection due to the lower fuel consumption for Bag 1 in the automatic idle speed configuration.

5.2.4 Driveability

Referring to Table 30 cold driveability ratings remained virtually unchanged between the base and modified car at the indicated test temperatures.

5.3 Propane Configuration

Preliminary testing was performed at -20°C in order to determine whether driveability problems would be encountered while running through the driving cycle. At this temperature it was discovered that there was insufficient heating capacity in the vaporizer and the vehicle would not perform as required. An additional two minute idle period was therefore added for all testing at -20°C where a block heater was not used. Testing at 0°C and +25°C was performed in the normal manner.

5.3.1 Fuel Consumption Results

The per cent change in fuel consumption of calibration B versus calibration A is summarized in Table 36 for Bags 1, 2 and 3 of the city cycle, the composite city cycle, and the highway cycle. The results are also shown graphically in Figure 142.

The following comparisions of calibration A to calibration B at +25°C, 0° and -20°C are made between test runs where no block heater was used. Referring to the +25°C test results, fuel consumption for calibration B was higher than for calibration A by 6.4% for Bag 1, 4.1% for the overall city cycle and 1.6% for the highway cycle. As both calibrations had similar engine and vaporizer related temperatures during and after warmup, (see Figures 86 to 89 and 90 to 93) as well as similar test conditions,(including barometric pressure and humidity) the higher fuel consumption of calibration B was unexpected, and is largely unexplainable. Some of the difference may be attributed to test-to-test variations, however a major portion must be attributed to other factors affecting the fuel consumption and testing of propane fueled vehicles that are not yet fully understood.

Fuel consumption results at 0°C showed an improvement for calibration B over A of 5.4% for the overall city cycle and 2.8% for the highway cycle. At -20°C, calibration B again showed an improvement over A during the city cycle of 3.6%. However, on the highway cycle fuel consumption was 3.7% higher for calibration B. These changes in fuel consumption were directly related to changes in CO emissions (see Table 37). In both the city and highway cycles at 0°C and -20°C, where fuel consumption decreased, CO levels decreased. This relationship of fuel consumption to CO level is not unusual, since leaner fuel/air ratios generally provide lower CO levels as well as lower fuel consumption. However, what was not expected was that the fuel/air ratio appeared to be leaner in calibration B than calibration A. Since calibration B was running with a cooler vaporizer temperature than calibration A, (Figures 134 to 137), therefore providing a cooler, denser charge of fuel, one would expect the fuel/air ratio in all cases to be richer for calibration B. This was not the case, as calibration B in most cases had lower CO levels than calibration A and therefore appears to have run leaner. One can conclude that the coolant temperature entering the vaporizer not only affects the density of the fuel vapour leaving the vaporizer, but also affects the operation of the unit in other ways, and that the tendency to richen the mixture at colder temperatures with the more dense fuel is overidden in some cases by these other factors. Further investigation is needed, possibly with externally controlled vaporizer temperatures and more instrumentation, to fully investigate the relationship between vaporizer operating temperature, fuel/air ratio and fuel consumption.

The use of a block heater with calibration A at -20°C improved Bag 1 fuel consumption 13% as a result of the higher initial engine and drive train operating temperatures, as well as the elimination of the 2 minute idle warmup required when the block heater was not used. The improvement in city cycle fuel consumption was 7.7% with the block heater. The highway cycle fuel consumption was 2.1% higher for the block heater test but appears to be a result of test-to-test variation as the comparisons were performed with the engine and vaporizer at approximately the same operating temperature. Comparision of the two block heater tests,one without heated intake air to the carburetor, (test 9.1.4B) and the other with heated intake air (test 9.1.4C), shows that the test with heated air had higher fuel consumption results. Overall, city cycle fuel consumption was higher by 0.6% and the highway by 1.5%. This slight difference may be due to the heated, less dense air richening the fuel-air ratio since the fuel temperature was the same for both tests. Overall, the effect of heated air intake on fuel consumption appears very small.

For testing at -35°C the oil was changed from 10w30 to 5w30 as per owners manual recommendations. A block heater was also used for this series of tests. Fuel consumption results were obtained for calibration A only, as it was found that in calibration B there was not adequate coolant flow to heat the vaporizer during the first minute of operation. The poor coolant flow was related to the increased coolant viscosity at -35°C, as well as to the coolant hose routing in calibration B, where the coolant had to travel a greater distance to reach the vaporizer (see Figure 35). In general, it appeared that calibration A had a coolant circuit that provided improved cold starting compared to calibration B.

A 2.5 minute idle was included prior to the city cycle to provide adequate heat to the vaporizer before the start of the driving cycle. Fuel consumption was 14.44 L/(100 km) for the overall city cycle and 10.49 L/(100 km) for the highway cycle. As compared to the -20°C results of calibration A without block heat the fuel consumption at -35°C was higher by 7.4% for the city cycle and 8.1% for the highway cycle.

5.3.2 Emissions Results

The per cent change in exhaust emissions of calibration B versus calibration A is summarized in Table 37 for Bags 1, 2, and 3 of the city cycle, the composite city cycle and the highway cycle. The composite city cycle exhaust emissions results are also shown graphically in Figure 143.

At the +25°C test temperature, HC and NO_x emissions were approximately the same between the calibrations while CO emissions were 21% lower for calibration B in the city cycle. Highway emissions were similar between the calibrations. Again at 0°C, HC and NO_x emissions were similar between calibrations for both the city and highway cycle, while CO emissions were 53% lower for calibration B for the city cycle, and 17% lower for the highway cycle. The lower CO emissions are probably a result of leaner fuel/air ratios in calibration B as explained in section 5.3.1.

Emissions results at -20°C showed calibration B to have approximately the same NO_x emissions and a reduction of HC and CO emissions of 35% and 34% respectively for the city cycle compared to calibration A. The relatively low HC emissions of calibration B compared to calibration A were due to an abnormally long crank time (26 seconds) and 2 die-outs during Bag 1 of one run for calibration A. No reasons were found for these events. The CO emission changes are believed to be related to changes in fuel/air ratio as discussed earlier in section 5.3.1. The highway cycle emissions were higher by 16% for CO and 13% for NO_x while the HC emissions remained virtually unchanged. Again, the CO results are probably related to changes in fuel/air ratio.

Comparing runs of calibration A at -20°C with and without block heat (tests 9.1.4B and 9.1.4) shows a reduction in HC emissions of 83% and CO emissions of 54% for Bag 1 with a block heater.

For the overall city cycle, the runs with a block heater showed a reduction in HC emissions of 62% and CO emissions of 59%. The highway emissions were similar between tests.

Comparing the tests for calibration A with block heat, with and without heated intake air (tests 9.1.4C and 9.1.4B), the test with heated intake air showed a reduction in CO emissions of 37% for the city cycle, with similar HC and NO_x emissions. Highway HC emissions were approximately the same while NO_x emissions were 21% higher and CO emissions 15% lower with heated intake air. The higher NO_x emissions on the highway are attributed to the higher temperature intake air increasing combustion chamber temperatures.

City cycle emissions at -35°C for calibration A with block heater (9.1.5-3), compared to -20°C tests with a block heater (9.1.4B) were higher by 23% for HC and 188% for CO, and lower by 15% for NO_x. The highway emissions were higher by 26% for HC and 41% for CO, and lower by 27% for NO_x. The high HC and CO emissions levels are probably a result of a richer fuel/air ratio caused by the cooler vaporizer as well as the heavier loads imposed by the higher horsepower setting and greater frictional losses at this temperature.

5.3.3 Driveability

Referring to Table 30, on-road driveability rating were not significantly different for the two calibrations tested, and in fact were similar to the ratings for the gasoline vehicles. However, in cold room testing at -20°C, it was found, as noted earlier, that the vaporizer was incapable of completely vaporizing the propane after a cold start, and this seriously impaired driveability. Some improvement was noted during preliminary testing of calibration A over calibration B, and calibration A was therefore used for the $-35^{\circ}C$ testing. Reasons for the apparent superiority of calibration A over calibration B are given in section 5.3.1.

5.4 Propane Versus Gasoline Comparisons

Gasoline vehicle no. 3 in its base configuration is used for comparision to the propane vehicle since this vehicle was similar to a standard car available to the public. The propane vehicle, no. 9, had a higher compression ratio than the gasoline vehicle (9.3:1 vs 8.2:1), and also had the air pump and EGR removed. Calibration B was used for comparision as this had more consistent fuel consumption and emissions results. Since the reported fuel consumption for vehicle no.9 was determined using the carbon balance method, the carbon balance fuel consumption results for vehicle no.3 are used for comparison as shown in Table 38.

5.4.1 Fuel Consumption Comparison

Based on the energy content of HD5 propane (approximately 23600 kj/litre lower heating value) compared with gasoline (approximately 32400 kj/litre lower heating value), the fuel consumption of a propane vehicle should be 37% higher assuming equal engine efficiency.

Referring to Table 39 the propane vehicle city cycle fuel consumption was higher than the gasoline vehicle by 33% at $25^{\circ}C$, 21% at $0^{\circ}C$, and 17% at $-20^{\circ}C$, while Bag 1 was higher by only 22% at $25^{\circ}C$ and 9.5% at $0^{\circ}C$, and lower by 0.8% at $-20^{\circ}C$. These differences between the overall city cycle and bag 1 fuel consumption results can in part be explained by the choke operation of the gasoline vehicle during warmup. With decreasing temperatures choke on times increased for the gasoline vehicle, wheras the propane vehicle had no choke (although it did have a fast idle system).

Highway fuel consumption of the propane vehicle was higher than the gasoline vehicle at all temperatures, but the difference between the two decreased with decreasing temperature. The propane vehicle highway fuel consumption was higher by 50% at 25°C, 37% at 0°C, and 32% at 20°C. (A similar trend was observed with calibration A, where highway cycle fuel consumption was higher than the gasoline vehicle by 47% at +25°C, 40% at 0°C, and 27% at -20°C.) This is likely due not only to the efficiency deteriorating in the case of the gasoline vehicle but also increasing in the case of the propane vehicle as the temperature decreases. In the case of the gasoline vehicle, the efficiency is likely to decrease somewhat as a result of poorer fuel vaporization in the colder intake manifold. This could at most account for a 6% penalty at -20°C since this was the total penalty observed in Phase 1 where horsepower settings remained constant for all temperatures. Since this cannot account fully for the trend noted, the efficiency of the propane engine probably improved to some extent at the lower test temperatures. The exact reason for this is not clear. As stated earlier, more research is needed to fully understand the factors affecting the operation of a propane fuel system at cold ambient temperatures.

Figure 144 shows the energy consumption of the vehicles based on kilojoules per kilometre. This indicates that over the city cycle the propane vehicle is more energy efficient than the gasoline vehicle and this advantage increases with decreasing temperature. Over the highway cycle the propane vehicle is slightly less efficient at 25°C but more efficient at 0°C and -20°C.

5.4.2 Emissions Comparision

Referring to the emissions results, shown in Tables 28 and 29, the propane vehicle had lower or equivalent HC and CO emissions over the city cycle than the base gasoline vehicle, while NO_x emissions were higher at all test temperatures. HC and CO emissions of the propane vehicle were lower than the gasoline vehicle by 41% and 0.5% at 25°C, 21% and 72% at 0°C, and 30% and 65% at -20°C, while NO_x emissions were higher by 45% at 25°C, 49% at 0°C, and 85% at -20°C. The lower HC and CO emissions are primarily due to the lack of fuel enrichment during warmup, as well as improved combustion after warmup, and the NO_x increase is due to the more advanced spark schedule during city driving and lack of exhaust gas recirculation.

Highway cycle HC, CO, and NO_x emissions of the propane vehicle were lower than the gasoline vehicle at all test temperatures. HC emissions were lower by 32% at 25°C, 35% at 0°C, and 32% at -20°C. CO emissions were lower by 23% at 25°C, 30% at 0°C, and 44% at -20°C. NO_x emissions were lower by 26% at 25°C, 22% at 0°C, and 18% at -20°C. As NO_x concentration is a function of fuel/air ratio, combustion temperature, and time, the lower NO_x emissions of the propane vehicle are most likely related to the lower spark advance on the highway cycle as compared to the base gasoline vehicle, and to the lower intake air temperature.

5.5 Fuel Consumption Versus Temperature Comparison - All Vehicles

Fuel consumption increases were noted with decreasing test temperature in all cases except the propane vehicle in configuration B between +25°C and 0°C. Table 40 displays the fuel consumption penalty occurring with decreasing temperature for all three vehicles in both configurations. For the two gasoline vehicles, an increase of 13% to 16% was noted at 0°C and 31% to 40% at

$-20^{o}C$ for the city cycle. For the highway cycle, the increase was somewhat less; 9% to 12% at $0^{o}C$ and 17% to 22% at $-20^{o}C$. For the propane vehicle this increase was less than for the gasoline vehicles in all cases. These trends are also shown graphically, Figure 145 for vehicle #3, and in Figure 142 for vehicle #9.

5.6 Problems Encountered And Solutions Implemented

A number of equipment problems were encountered and rectified during the program. The following items concerning the exhaust emission measuring equipment may require further development for future programs:

- While analysing the emissions from the cold transient portion of the city cycle at a test temperature of $-20^{o}C$, the CO and HC analysers repeatably went off scale on the highest range. This problem was reduced by installing a larger critical flow venturi, thereby increasing the dilution of the exhaust gases with ambient air. However, this could still be a potential problem for testing of larger vehicles.

- When comparing the fuel consumption values acquired from the gravimetric system and the carbon balance method, there was a large discrepancy between the two, with the carbon balance always being lower. This was most noticeable in the cold transient and hot transient portions of the city cycle. After consultation with Transport Canada and Shell Research, the flexible pipe from the vehicle tailpipe to the cold room wall was insulated to prevent possible condensation of the hot exhaust gases on the cold pipe. A lesser discrepancy still exists and Table 41 summarizes the percentage difference in fuel consumption from the two measurement systems. For the composite city cycle the discrepancy was approximately 8% and for the highway cycle 5 to 6%. Attempts to recalibrate the emissions bench did not solve the problem.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Optimized spark advance and automatic control of idle speed both provided significant improvements in fuel consumption during engine warmup at cold ambient temperatures.

6.1.2 Compared to the base gasoline vehicles, cold driveability improved slightly with the use of optimum cold timing. The automatic idle speed control had a minimal effect on vehicle driveability.

6.1.3 The efficiency of the propane vehicle relative to the gasoline vehicle increased with decreasing temperature both in city and highway type driving.

6.1.4 Driveability of the propane vehicle was comparable to the gasoline vehicles at 0°C or greater ambient temperature. However, at -20°C driveability was severely affected by the vaporization capability of the fuel system. The use of a block heater prior to the test aided in fuel vaporization, improved fuel consumption and reduced exhaust emissions.

6.1.5 Compared to the results obtained in Phase I, the increase in fuel consumption with decreasing temperature was significantly greater during Phase II especially for the highway cycle. This was due to the higher horsepower settings used in Phase II to better approximate the additional aerodynamic drag and rolling resistance which occur at colder temperatures.

6.1.6 The use of optimum cold timing increased HC emissions during Bag 1 of the city cycle at all test temperatures. NO_x emissions in Bag 1 also increased at the colder temperatures. At the +25°C test temperature, however, the increase in overall city cycle HC and NO_x emissions was minimal.

CO emission changes varied and were judged not to be a result of optimum cold timing.

6.1.7 The use of automatic idle speed control resulted in a substantial increase in city cycle HC emissions at all test temperatures, primarily as a result of decreases in Bag 1 emissions levels.

CO emissions increased significantly at +25°C as a result of increased emissions levels in Bags 2 and 3. CO emissions also increased to a lesser extent at 0°C, but decreased at -20°C.

NO_x emissions remained virtually unchanged at +25°C, decreased at 0°C, and increased at -20°C.

6.1.8 For the propane vehicle, city cycle HC and CO emissions were lower than for the gasoline vehicle at all test temperatures. NO_x emissions were higher at all test temperatures.

6.1.9 All of the vehicle modifications tested have the capability of meeting present emissions standards if implemented in production.

6.2 Recommendations For Future Work

6.2.1 It would be useful to review the results of these tests in relation to the normal on-road use of vehicles.

6.2.2 The automatic idle speed configuration improved fuel consumption in Bag 1. There was however a penalty in Bag 2 which caused an overall penalty for the city cycle at test temperatures of $0^{\circ}C$ and above. Further development is necessary to achieve an improvement over the city cycle at all temperatures.

6.2.3 It was established that all configurations tested in Phases I and II yielded fuel consumption improvements during at least a portion of the driving cycle at low ambient conditions. It would be of interest to develop and test a vehicle which incorporates a combination of two or more of the modifications.

6.2.4 Testing could be done to determine the fuel consumption penalty resulting from fuel condensation in the intake manifold of a fully warmed up engine operating at cold ambient temperatures. This could be done by testing a vehicle with a fully insulated or heated intake manifold.

6.2.5 There appears to be limited data on the relative cold weather performance of existing vehicle technologies. Specific information would be useful on:

a) single and/or multi-point gasoline injection versus conventional carburetion; and,

b) manual versus automatic transmission efficiency.

6.2.6 The driving cycle specified for emission and fuel consumption testing at +20°C to +30°C is not ideal for cold temperature testing, and vehicles have trouble meeting the required acceleration immediately after startup. This can affect repeatability as well as being unrealistic. A modified cycle may be appropriate for extended future cold weather testing, possibly incorporating a longer initial idle and/or less aggressive initial acceleration.

6.2.7 The following development work is recommended to improve the cold weather emissions and fuel consumption test facility.

a) Investigation into the discrepancy between the gravimetric and carbon balance fuel consumption measurement.

b) Modification to the HC and CO analysers to increase the maximum HC and CO readings consistent with measurements that can occur in cold weather testing.

c) Cross-correlation of emissions measurement with other laboratories (absolute measurements were not critical for this program).

d) Refinement of the data acquisition system to improve its versatility for possible future programs.

e) Provision of cold room temperature control to enable testing between 0°C and room or outside ambient temperatures.

REFERENCES

1. Test Fuel Specifications Report, Q.E.T.E.

2. Constant Volume Sampler, Model CVS-20B. Emissions Analysis Systems; Operation and Maintenance Manual; Horiba Instruments Incorporated.

3. Standard Gas Divider; Instruction Manual, Horiba Instruments Incorporated.

4. Critical Flow Orifice Kit; Instruction Manual, Horiba Instruments Incorporated.

5. NO_x Generator Model 210; Instruction Manual, Horiba Instruments Incorporated.

6. Transport Canada Voluntary Motor Vehicle Fuel Consumption Program-Guidelines for 1980

7. Motor Vehicle Safety Test Methods Chapter lV Section 1101 - Vehicle Emissions, Approved 1 September, 1974 Transport Canada Road Safety.

Vehicle No.	V.I.N. (last 6 digits)	Configuration No.	Configuration
1	109222	1	Optimum Cold Timing
3	117590	3	Automatic Idle Speed
9	118220	9	Propane

TABLE 1 - Test Vehicle Identification

TESTS	RESULTS
Octane, Research	91.3
Octane, Motor	85.6
Specific Gravity (at 15°C/60°F) kg/L	.7090
Lead Organic mg/L	.332
Distillation Range	
IBP, °C	27
10%, °C	37
50%, °C	78
90%, °C	158
E.P., °C	210
Sulfur (%)	.04
Phosphorus, mg/L	.0000
RVP (Reid Vapour Pressure) kPa	95.7
Olefins (%)	10.2
Aromatics (%)	16.4
Saturates (%)	73.4
Existent Gum mg/100 mL	0.4
Colour	Straw/Bronze
Appearance	Clean & Clear, no visible free water

Table 2 - Test Fuel Specifications (Leaded Gasoline)
(See Reference 1 for more detail)

PROPANE TEST FUEL ANALYSIS

	% by Volume
Ethane	3.0
Propane + propylene	96.3
Isobutane	0.6
Normal Butane	0.1
Carbon to Hydrogen Ratio = 2.6667	

Table 3 - Propane Test Fuel Analysis

THERMO-COUPLE NO.	LOCATION	VEHICLE CONFIGURATION NO.			THERMO-COUPLE TYPE	PROBE* TYPE	PROBE SHEATH or Wire Dia.	LOCATION DETAILS
		1	3	9				
20	COOLANT - THERMOSTAT	X	X	X	J	S	.125	Thermostat Housing
21	COOLANT - LOWER RAD HOSE	X	X	X	J	S	.125	At Outlet of Rad
22	COOLANT - HEATER CORE IN	X	X	X	J	B	20 ga	
23	COOLANT - HEATER CORE OUT	X	X	X	J	B	20 ga	
24	COOLANT - ENGINE BLOCK IN	X	X	X	J	B	20 ga	
25	CARB AIR IN (1)	X	X	X	J	B	24 ga	
26	CARB AIR IN (2)	X	X	X	J	B	30 ga	
27	FRESH AIR DUCT	X	X	X	J	B	24 ga	
28	INTAKE MANIFOLD RUNNER	X	X	X	J	B	20 ga	In #4 Runner 2" From Cyl. Head
29	STOVE OUTPUT	X	X		J	B	24 ga	
30	ENGINE OIL AT DIPSTICK	X	X	X	J	B	24 ga	At Tip of Dipstick
31	TRANSMISSION OIL AT DIPSTICK	X	X	X	J	B	24 ga	At Tip of Dipstick
32	UNDERHOOD BY CARB	X	X	X	J	B	24 ga	
33	UNDERHOOD BY FUEL PUMP	X	X	X	J	B	24 ga	
34	DIFFERENTIAL OIL	X	X	X	J	B	24 ga	
35	HEATER DUCT - LEFT	X	X	X	J	B	20 ga	
36	HEATER DUCT - RIGHT	X	X	X	J	B	24 ga	
37	IN CAR AIR	X	X	X	J	B	24 ga	
38	FUEL IN-CARB BOWL	X	X		J	S	.125"	
39	FUEL IN-MIXER			X	J	B	20 ga	
40	CARB ABOVE THROTTLE BLADE			X	J	B	24 ga	
41	COOLANT - VAPOURIZER OUT			X	J	B	20 ga	
42	FUEL TANK			X	J	B	24 ga	
43	FUEL - VAPOURIZER IN			X	J	S	.0625	
44	VAPOURIZER SURFACE			X	J	B	24 ga	
45	FUEL IN - AT COLD ROOM WALL	X	X					
46	AMBIENT - AT COLD ROOM WALL	X	X	X				
50	GLYCOL (PAU OUTLET)	X	X	X				
51	LEFT INERTIA WT. ENCLOSURE	X	X	X				
52	RIGHT INERTIA WT. ENCLOSURE	X	X	X				
	DRIVERS AID HEAT ENCLOSURES							
53	PAU ENCLOSURE	X	X	X				

NOTES: *PROBE TYPE B - Bead Type Exposed Junction
S - Stainless Steel Sheath With Grounded Junction

Table 4 - Thermocouple Types & Locations

Number	INSTRUMENTATION/SENSOR			
	SENSED PARAMETER	MANUFACTURER/DESCRIPTION	MODEL #	SERIAL #
1	Throttle Position	CHRYSLER	4267126	--
2	Stove Door Position	CHRYSLER	4267126	--
3	Battery Voltage	Cable from Vehicle Battery to Watanabe Recorder	---	---
4	Manifold Vacuum	Schaevitz - Readout & Pressure Transducer	MTDR-3505 P724-0001	406 12633
5	Choke Position	Schaevitz RVDT	R30A	3334 3375
6	Engine Speed	Snap-On-Magnetic Pickup And Meter With Output	MT455A	2975
7	Ignition Timing	Snap-On- Inductive Pickup And Meter With Output	MT455A	2975
8	Fuel Pressure	Shaevitz - Readout & Pressure Transducer	MTDR-3505 P723-0001	407 10926

Table 5 - Vehicle Parameter Sensors

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
1	Exhaust Gas Sampling System				
	Constant Volume Sampling Unit	Sampling, mixing, metering and distribution of vehicle exhaust and ambient air	HORIBA	CVS 20B	
	Compressor	Provides flow of exhaust gases and ambient air through sampler unit	SPENCER		
	Control Unit	Control for various modes of operation - sample, purge, analyze, etc.	HORIBA		
	Sample Storage Unit	Storage of ambient air and dilute exhaust samples for analysis	HORIBA		
2	Exhaust Gas Analysing System		ANALYGAS		
	Total Hydrocarbon Content Analyzer	Analysis of hydrocarbon concentration	HORIBA	FIA-23	47668
	Oxides of Nitrogen Analyzer	Analysis of NOx concentration	HORIBA	CLA-22A	477502
	Carbon Monoxide Analyzers	Analysis of CO concentration	HORIBA	AlA 23A	--------
	Carbon Dioxide Analyzer	Analysis of CO_2 concentration	HORIBA	AlA-23	A47484035
	NOx Generator	Production of NO_2 from NO & O_3 used in converter efficiency check	HORIBA	210	--------

Table 6 - Exhaust Emissions Bench Components

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
2	(Cont'd)				
	Calibration, Span and Zero Gases	Gases used to calibrate analysers and set zero	MATHESON		
	Standard Gas Divider	Linearity calibration check of analysers	HORIBA	SGD-78	732281

Table 6 - Exhaust Emissions Bench Components (Cont'd)

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
1	Datalogger System with Options	Recording of Fuel Consumed, Dyno Roll Revs, % RH, Fuel Pressures, All Thermocouples	DIGITEC	3000-2	47290612
2	Computer	Storage & display of Temperatures and other digital data from Datalogger Calculation of results	DIGITAL	OBA11-UA	AB02416
3	Printer	Provides hard copy of digital data from datalogger	CENTRONICS	730-1	14054
4	Video Display Terminal	Input, Output of data and control of digital computer	DIGITAL	VT100-AA	ABA4922
5	6 Channel Analog Recorder	Record of Vehicle Parameters 1. Throttle position 2. Battery Voltage & Stove door position 3. Manifold Vacuum 4. Choke Position & Propane Vapour Temp. (Mixer) Inlet Carburetor 5. Ignition Timing 6. Engine Speed	WATANABE	MC6612-6H	98511015

Table 7 - Equipment/Instrumentation

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
6	Weigh Scale 30000 gm	Measurement of Fuel Consumed	SARTORIOUS	3806MP	B1229-105
	Connector for digital output			1056-01	B1229-191
	Interface Box	Interface to Digitec		7053-05	2906065
7	Fibre optic Tachometer	Dyno Roll Revs	SPECTRAL DYNAMICS	SD43-GPT-1	
	Head Assembly			13134	1052
	Electronics			13135	1139
8	Pulse totalizer	Count of Dyno Roll Revs	DATA-PRECISION	5740	10733
9	Digital Humidity Analyser & Display	% Relative Humidity Dew Point	EG & G DEW-ALL	911	0298
10	Humidity Sensor	Dilution Air	ARCHER		
11	Dynamometer Road Load Power Control	Vehicle Road Load Simulation	CLAYTON	CTE50	
		Dynamometer Control		A-34064-3-486	
12	Coast Down Timer	Dynamometer Frictional Horsepower Determination	TRANSPORT CANADA		1
13	Drivers Aid Recorder	Driving Cycle Display & Permanent Record	AESI	DA 1750	38632
14	Engine Analyser	Scheduled Vehicle Maintenance	MARQUETTE	40276	457432
15	Propane Enrichment Kit	Carburetor Idle Mixture Setting	CLIPPARD	MJV-2	
			KENT-MOORE	J26911	

Table 7 - Equipment/Instrumentation (Cont'd)

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
16	Digital Voltmeter	Dyno Calibration and Instrumentation Trouble Shooting	HEWLETT PACKARD	3490A	1211A02889
17	BIPOLAR Power Supply	Dyno Calibration	HEWLETT PACKARD	6825A	1612A00316
18	X-Y Plotter	Dyno Calibration	HEWLETT PACKARD	7046A	
19	Oscilloscope	Dyno Calibration	GOULD	0S3300B	661
20	X-Y Plotter	Plotting of Digitec Data	CALCOMP	862811100	853934
21	Stopwatch	Driveability Testing and Dyno Test Elapsed Times	CANLAB GCA PRECISION SCIENTIFIC	69320	
22	Cooling Fan	Vehicle Engine Cooling during Dyno Test	HARTZELL	23-36-WL4	37616
23	Cooling Fans 5000 CFM 18" Special	Vehicle Tire Cooling during Dyno Test	BUFFALO	G400	76-M-426
24	Safety Straps 15" c/w hooks	Test Vehicle Tie-Down During Dyno Testing		13P	
25	Battery Charger	Recharge Vehicle Battery	WABASH	B-10A	
26	Battery & Coolant Tester	Test Battery and Engine Coolant	AO DUO CHECK	7181	
27	Vacuum Tester	Test Engine Vacuum	MARQUETTE	41-221	

Table 7 - Equipment/Instrumentation (Cont'd)

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
28	Tire Pressure Gauge 0 - 60 psi	Measure Vehicle Tire Pressure	PRECISION		
29	Electrical Fuel Pump	Fuel Supply Pump	DUPREE	12V801	
30	Fuel Pressure Regulator 2 - 6 psi	Limit Fuel Supply Line Pressure	FISHER CONTROLS	95L	
31	Fuel Pressure Regulator	Limit Carb.-in-fuel Pressure	HOLLEY	34R-66578	
32	Pressure Gauge	Fuel Pressure	ASHCROFT		
33	Fuel Canisters	Fuel Storage			
34	Fittings, valves, quick disconnects	Fuel Supply System	SWAGELOCK		
35	SOLENOID VALVE	Fuel Bypass	CHRYSLER	4085397	
36	MINI	Dyno Warmup Vehicle	AUSTIN		
37	PINTO	Dyno Coastdown Vehicle	FORD		
38	Air Hydraulic End Lift	Dyno coastdowns	BISHMAN	420	281

Table 7 - Equipment/Instrumentation (Cont'd)

NO.	DESCRIPTION	APPLICATION	MANUFACTURER	MODEL NO.	SERIAL NO.
39	Charcoal Vapour Canister	Slave Canister to absorb evaporative emissions during Hot Soak and for cold start repeatability	CHRYSLER	4241836	
40	Mercury Barometer	Cold Room Barometric Pressure	FISHER SCIENTIFIC		

Table 7 - Equipment/Instrumentation (Cont'd)

Test Temperature °C	Dynamometer Road Load Power at 50 mph
25	7.9
0	8.6
-20	10.0
-35	11.1

Table 8 - Dynamometer Road Load Power Settings for Different Test Temperatures

		TEST TEMPERATURES °C			
		-35	-20	0	25
CITY CYCLE	Heater Control	Max Heat	Max Heat	Max Heat	OFF
	Fan*	High	High	Low	OFF
HIGHWAY CYCLE	Heater Control	Max Heat	Max Heat	Max Heat	OFF
	Fan*	Medium	Medium	Low	OFF

* 3 Speed Fan - High
Medium
Low
OFF

Table 9 - Heater Settings At Different Test Temperatures

```
                         TEST DATA SUMMARY

TEST NO=1131          COLD ROOM CONDITIONS/DILUTION AIR CONDITIONS
DATE  =13-MAY-82      AVE TEMP =  0C         AVE TEMP=  22C
TIME  =09:20          BAR PRESS= 758MMHG  HUMIDITY=31 %
CAR NO=   1           HUMIDITY=  71%
                      H      = 18GRAINS H2O/LB DRY AIR

                             INPUT DATA

  PARAMETER          BAG1         BAG2        BAG3   HIGHWAY


FUEL USED              523.         909.       1264.       801.
DYNO REVS             8394.       17403.      25801.     24001.
CVS VOLUME            2852.        4896.       2858.      4339.
HCE                186.000       92.000     130.000    162.000
HCD                  7.000        6.000       7.000      8.000
NOXE               100.800       71.600     144.300    283.500
NOXD                 1.300        1.100       1.200      3.600
CO RANGE                 0            0           0          0
COEM              1570.000      183.000     251.000    171.000
CODM                13.000        1.000       1.000      1.000
CO2E                0.7800       0.4700      0.7100     1.1300
CO2D                0.0400       0.0400      0.0400     0.0400

                          CALCULATION DATA

FUEL                   523.         386.        355.       801.

DREVS                 8394.        9009.       8398.     24001.

FSG=0.7088
DHC=16.33
KH=0.788706

COE               1570.000      183.000     251.000    171.000
COD                 13.000        1.000       1.000      1.000

DF                 14.0226      26.9347     17.9120    11.5190
HCMAS                8.360        6.894       5.759     10.961
NOXMAS              12.133       14.753      17.478     51.936
COMAS              146.493       29.385      23.562     24.332
CO2MAS            1098.502     1095.358     996.164   2460.063
```

Table 10 - Sample Printout Of Data & Results

```
              TEST RESULTS SUMMARY   1131
              ----------------------------

                        BAG1          BAG2          BAG3
  HC  G/KM (G/MI)     1.441( 2.319) 1.107( 1.782) 0.992( 1.597)
  NOX G/KM (G/MI)     2.091( 3.366) 2.369( 3.813) 3.011( 4.846)
  CO  G/KM (G/MI)    25.251( 40.64) 4.719( 7.595) 4.059( 6.533)
  CO2 G/KM (G/MI)     189.3( 304.7) 175.9( 283.1) 171.6( 276.2)

 FUEL CONS. L/100KM      9.974         7.978         7.735

 FUEL ECON MPIG (US) 28.32 (23.58)  35.41 (29.48)  36.52 (30.41)

   BAG TEST RESULTS(GRAVIMETRIC)

 FUEL CONS L/100KM     12.718          8.746         8.629

 FUEL ECON MPIG (US)  22.21 (18.49)  32.30 (26.89)  32.74 (27.26)


   TEST RESULTS WEIGHTED CITY,AND HIGHWAY

                           CITY         HIGHWAY
  EMISSIONS

  HC  G/KM (G/MI)     1.145( 1.842)   0.661( 1.063)
  NOX G/KM (G/MI)     2.488( 4.004)   3.131( 5.039)
  CO  G/KM (G/MI)     8.796(14.156)   1.467( 2.361)
  CO2 G/KM (G/MI)   177.52(285.69)  148.30  (238.67)

  FUEL CONSUMPTION /ECONOMY

 (FROM CARBON BALANCE)

 FUEL CONS L/100KM      8.325           6.520

 FUEL ECON MPIG (US) 33.93 (28.26)    43.33 (36.08)


 (FROM GRAVIMETRIC),

 FUEL CONS L/100KM      9.538           6.812

 FUEL ECON MPIG (US) 29.62 (24.66)    41.47 (34.53)
```

Table 10 (Cont'd)

PARAMETER / TEST RUN	1.1.2-3	1.2.2-2	1.1.3-2	1.2.3-3	1.1.4-8	1.2.4-9
Coolant - Thermostat	✓	✓	✓	✓	✓	✓
Coolant - Lower Rad. Hose	✓	✓	✓	✓	✓	✓
Coolant - Heater in	✓	✓	✓	✓	✓	✓
Coolant - Heater out	✓	✓	✓	✓	✓	✓
Carb. Air in	✓	✓	✓	✓	✓	✓
Int. Manifold Runner	✓	✓	✓	✓	✓	✓
Stove Output	✓	✓	✓	✓	✓	✓
Eng. Oil @ Dipstick	✓	✓	✓	✓	✓	✓
Trans. Oil @ Dipstick	✓	✓	✓	✓	✓	✓
Heater Duct - Left	✓	✓	✓	✓	✓	✓
Heater Duct - Right	✓	✓	✓	✓	✓	✓
In Car Temp.	✓	✓	✓	✓	✓	✓
Fuel in Carb. Bowl	✓	✓	✓	✓	✓	✓
Fuel Consumed	✓	✓	✓	✓	✓	✓

Table 11 - Summary of Parameters Plotted for Fuel Consumption Tests of the Optimum Cold Spark Timing Configuration (Vehicle 1)

PARAMETER \ TEST RUN	3.1.2-3	3.2.2-2	3.1.3-3	3.2.3-1	3.1.4-1	3.2.4-2
Coolant - Thermostat	✓	✓	✓	✓	✓	✓
Coolant - Lower Rad. Hose	✓	✓	✓	✓	✓	✓
Coolant - Heater in	✓	✓	✓	✓	✓	✓
Coolant - Heater out	✓	✓	✓	✓	✓	✓
Carb. Air in	✓	✓	✓	✓	✓	✓
Int. Manifold Runner	✓	✓	✓	✓	✓	✓
Stove Output	✓	✓	✓	✓	✓	✓
Eng. Oil @ Dipstick	✓	✓	✓	✓	✓	✓
Trans. Oil @ Dipstick	✓	✓	✓	✓	✓	✓
Heater Duct - Left	✓	✓	✓	✓	✓	✓
Heater Duct - Right	✓	✓	✓	✓	✓	✓
In Car Temp.	✓	✓	✓	✓	✓	✓
Fuel in Carb. Bowl	✓	✓	✓	✓	✓	✓
Fuel Consumed	✓	✓	✓	✓	✓	✓

Table 12 - Summary of Parameters Plotted for Fuel Consumption Tests of the Automatic Idle Speed Control Configuration (Vehicle 3)

PARAMETER / TEST RUN	9.1.2-2	9.2.2-1	9.1.3-1	9.2.3-1	9.1.4-1	9.2.4-1	9.1.5-3	914B-2	914C-1
Coolant - Thermostat	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coolant - Lower Rad. Hose	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coolant - Heater in	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coolant - Heater out	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carb. Air in	✓	✓	✓	✓	✓	✓	✓	✓	✓
Int. Manifold Runner	✓	✓	✓	✓	✓	✓	✓	✓	✓
Eng. Oil @ Dipstick	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trans. Oil @ Dipstick	✓	✓	✓	✓	✓	✓	✓	✓	✓
Heater Duct - Left	✓	✓	✓	✓	✓	✓	✓	✓	✓
Heater Duct - Right	✓	✓	✓	✓	✓	✓	✓	✓	✓
In Car Temp.	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fuel - Vaporizer in	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coolant - Vaporizer out	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 13 - Summary of Parameters Plotted for Fuel Consumption Tests of the Propane Configuration (Vehicle 9)

PARAMETER	CHANNEL NO.	PEN COLOUR	RECORDER SCALE	EQUIVALENT PARAMETER SCALING
THROTTLE POSITION	1	Red	10V	12.7%/cm (32%/inch)
BATTERY VOLTAGE (During Cold Start)	2	Black	20V	0.79V/cm (2V/inch)
STOVE DOOR POSITION (During Test Run)	2	Black	20V	45%/cm (111%/inch)
MANIFOLD VACUUM	3	Purple	200 mV	5.3 kPa/cm (4 inches Hg/inch)
CHOKE POSITION (Vehicles 1 & 3)	4	Brown	10V	18.77%/cm (47.7%/inch)
SPARK ADVANCE	5	Blue	50 mV	3.9 Deg/cm (10°/inch)
ENGINE SPEED	6	Green	50 mV	3.94 rpm/cm (1000 rpm/inch)
FUEL MIXER FUEL IN TEMP. (VEHICLE 9)	4	Brown	5 mV	See Figure 15

Table 14 - Watanabe Recorder Output & Scaling

EXAMPLE TEST NO.: 3 . 2 . 3 - 4

VEHICLE NO:

1 = Optimum Cold Timing Vehicle
3 = Automatic Idle Speed Vehicle
9 = Propane Vehicle

TEST SERIES:

T = Trial Runs
H = Heater Test Trial
A,B,C,D = Calibration Comparisons

For Vehicles #1 & 3

1 = Tests on Base Vehicle
2 = Tests on Exp. Hardware

For Vehicle #9

1 = Tests on Exp. Hardware A
2 = Tests on Exp. Hardware B

TEST TYPE AND TEMP:

1 = On-Road Driveability at Prevailing Temperature
2 = City & Hwy Cycle @ +25°C
3 = City & Hwy Cycle @ 0°C
4 = City & Hwy Cycle @ -20°C
5 = City & Hwy Cycle @ -35°C
4B,4C = City & Hwy Cycle @ -20°C with block heat (see Table 18)

TEST RUN NO:

Identifies Individual Run No.
(Max. of 4 runs done for each combination of the above items)
0 = Preconditioning Run
1,2,3... = Test Run

Table 15 - Test Number Interpretation

Note: Table not applicable to preliminary tests on Vehicle #9.

VEHICLE # 1 OPTIMUM COLD TIMING

V.I.N. 109222 (last 6 Digits)

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMP. (°C)	TEST RESULTS TABLE NO.
PRELIMINARY TESTS				
1.T.2	Modified - Calibration A	Fuel Consumption - Emissions Trial Runs - Dynamometer	25	
1.H.4	Modified - Calibration A	Fuel Consumption - Emissions Trial Run to determine Heater settings at low ambient temperature	-20	
1.A.4	Modified - Calibration A	Fuel Consumption & Emissions Calibration Comparison Runs - Dynamometer		31
1.B.4	Modified - Calibration B			31
1.C.4	Modified - Calibration C			31
T1B1-1	Base Vehicle	Trial Run	-20	
FINAL TESTS**				
1.1.1	Base Vehicle	Driveability	Ambient	30
1.1.2	Base Vehicle	Fuel Consumption - Emissions Dynamometer	+25	24,27, 32,33,40
1.1.3	Base Vehicle	Fuel Consumption - Emissions Dynamometer	0	
1.1.4	Base Vehicle	Fuel Consumption - Emissions Dynamometer	-20	
1.2.1	Modified - Calibration C	Driveability	Ambient	30
1.2.2	Modified - Calibration C	Fuel Consumption - Emissions Dynamometer	+25	24,27, 32,33,40
1.2.3	Modified - Calibration C	Fuel Consumption - Emissions Dynamometer	0	
1.2.4	Modified - Calibration C	Fuel Consumption - Emissions Dynamometer	-20	

** Note: Emissions Equipment was recalibrated and the flexible tubing joining the test vehicle tailpipe to the sampling equipment insulated between preliminary tests and final tests.

Table 16 - Summary of Tests Performed on Vehicle # 1
Optimum Cold Timing

VEHICLE #3 AUTOMATIC IDLE SPEED CONTROL

V.I.N. 117590 (last 6 digits)

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMP. (°C)	TEST RESULTS TABLE NO.
PRELIMINARY TESTS				
3.T.2	Modified	Emission Equipment Trials	+25	
3.H.4	"	Heater Setting Evaluation	-20	
3.A.4-1	Modified	PROM A-1 Evaluation		
3.B.4-1	"	PROM A Evaluation	-20	
3.B.4-2,3	"	PROM A-1' Evaluation	-20	
3.D.4-3	"	PROM A-2 Evaluation	-20	
FINAL TESTS**				
3.1.1	Base Vehicle	Driveability	Ambient	30
3.1.2	Base Vehicle	Fuel Consumption & Emissions Dynamometer	+25	25,28,34,35, 38,40,41
3.1.3	Base Vehicle	Fuel Consumption & Emissions Dynamometer	0	
3.1.4	Base Vehicle	Fuel Consumption & Emissions Dynamometer	-20	
3.2.1	Modified	Driveability	Ambient	30
3.2.2	"	Fuel Consumption & Emissions Dynamometer	+25	25,28,34, 35,40
3.2.3	"	Fuel Consumption & Emissions Dynamometer	0	
3.2.4	"	Fuel Consumption & Emissions Dynamometer	-20	

** NOTE: Emissions Equipment was recalibrated and the flexible tubing joining the test vehicle tailpipe to the sampling equipment insulated between preliminary tests and final tests.

Table 17 - Summary of Tests Performed on Vehicle #3
Automatic Idle Speed Control

VEHICLE #9 PROPANE

V.I.N. 118220 (last 6 digits)

TEST NUMBER	HARDWARE CONFIGURATION	TESTING PERFORMED	TEST TEMP. (°C)	TEST RESULTS TABLE NO.
PRELIMINARY TESTS				
911D1	Calibration A	PROM AP1 Evaluation	-20	
921D1	Calibration A	PROM 2PB Evaluation	-20	
921T2	Calibration A	PROM AP1 with revised idle set	-20	
911T1	Calibration A	PROM AP1 with idle vacuum advance	-20	
FINAL TESTS**				
9.1.1	Calibration A	Driveability	Ambient	30
9.1.2	Calibration A	Fuel Consumption & Emissions Dynamometer	+25	26,29,36 37,40
9.1.3	Calibration A	Fuel Consumption & Emissions Dynamometer	0	
9.1.4	Calibration A	Fuel Consumption & Emissions Dynamometer	-20	
9.1.5	Calibration A with 5 hr Blockheat	Fuel Consumption & Emissions Dynamometer	-35	
9.1.4B	Calibration A with 2 hr Blockheat	Fuel Consumption & Emissions Dynamometer	-20	
9.1.4C	Calibration A with 2 hr Blockheat + Heated Intake Air	Fuel Consumption & Emissions Dynamometer	-20	
9.2.1	Calibration B	Driveability	Ambient	30
9.2.2	Calibration B	Fuel Consumption & Emissions Dynamometer	+25	26,29,36, 37,39,40
9.2.3	Calibration B	Fuel Consumption & Emissions Dynamometer	0	
9.2.4	Calibration B	Fuel Consumption & Emissions Dynamometer	-20	
9.2.5	For initial -35° testing	Fuel Consumption & Emissions Dynamometer	-35	

**NOTE: Emissions Equipment was recalibrated and the flexible tubing joining the test vehicle tailpipe to the sampling equipment insulated between preliminary tests and final tests.

Table 18 - Summary of Tests Performed on Vehicle #9
Propane Configuration

TABLE 19

VEHICLE NO. 1 OPTIMUM COLD TIMING

BASE VEHICLE SPECIFICATIONS **

1. GENERAL

Engine - Displacement	1.7L
- Compression Ratio	9.5:1
Transmission	3 speed auto
Axle Ratio	3.48:1
Carburetor	Holley 5220 Series Chrysler P/N 5214324

2. CARBURETOR SPECIFICATIONS

Idle Speed (RPM)	850
Propane Enriched Idle Speed (RPM)	950
Hot Fast Idle Speed (RPM)	1700
Throttle Stop Speed (RPM)	550
Vacuum Kick	0.040"
Fast Idle Cam Index	0.040"
Choke Index	2 Notches Rich

(Cont'd)

** The base vehicle specifications, including carburation and ignition timing specifications, were developed especially for the high compression engine used in the vehicle, and are therefore, in most cases different than the specifications for vehicle No. 3, in the base configuration

TABLE 19 (Cont'd)

3. ELECTRONIC SPARK ADVANCE SPECIFICATIONS

	Cold and Warm Engine Timing
General	
Advanced during Cranking	10°
Basic Advance	17°
Coolant Switch	Yes *(66°C)
Vacuum Accumulator (Clock)	No
Maximum Advance	45°
Start to Run Speed (rpm)	800
Run to Start Speed (rpm)	200
Governor Advance	
(Degrees @ rpm)	0° @ 2200
	4° @ 2600
	4° @ 3000
	8° @ 3400

Vacuum Advance	Cold*	Warm
(Degrees @ Hg Vacuum)	No Vacuum	0° @ 1"
	Advance	25° @ 13"

Speed/Vacuum Limiting Curve	
(Degrees @ rpm)	8° @ 1000
	21° @ 1700
	25° @ 2200
Start Transient	
Maximum Advance	5°
Constant Duration (secs)	15
Decay Time (secs)	15
Attenuation Break Point #1 (rpm)	2000
Attenuation Break Point #2 (rpm)	3000

* The coolant switch cancels all vacuum advance at engine coolant temperatures below (66°C).

TABLE 19 (CONT'D)

Notes: Timing Specifications

1. Vacuum and governor advance are additive to basic timing.

2. The vacuum accumulator, or clock function (count-up time, count-down time and zero time offset) scales the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed.

3. Governor and vacuum spark advance curves are essentially linear between the points specified.

4. The"start-to-run" speed is the speed at which the computer switches from crank timing to run (Basic + Governor + Vacuum + Start Transient) timing. The computer reverts back to crank timing if the engine speed falls below the "run-to-start" speed.

TABLE 20

VEHICLE NO. 1 OPTIMUM COLD TIMING

MODIFIED VEHICLE SPECIFICATIONS

1. GENERAL

Engine - Displacement	1.7L
- Compression Ratio	9.5:1
Transmission	3 speed auto
Axle Ratio	3.48:1
Carburetor	Holley 5220 Series Chrysler P/N 5214324

2. CARBURETOR SPECIFICATIONS

Idle Speed (RPM)	850
Propane Enriched Idle Speed (RPM)	950
Hot Fast Idle Speed (RPM)	1400
Throttle Stop Speed (RPM)	550
Vacuum Kick	0.040"
Fast Idle Cam Index	0.040"
Choke Index	2 Notches Rich

(...cont'd)

TABLE 20 (Cont'd)

3. ELECTRONIC SPARK ADVANCE SPECIFICATIONS

	COLD ENGINE * TIMING			WARM ENGINE TIMING
	CALIBRATION **			
	A	B	C	
General				
Crank Advance	10°	10°	10°	10°
Basic Advance	20°	20°	21°	17°
Coolant Switch	No	No	No	No
Vacuum Accumulator (Clock)	No	No	No	No
Maximum Advance	45°	45°	45°	45°
Start To Run Speed(rpm)	800	1000	1000	800
Run to Start Speed(rpm)	300	300	300	200
Governor Advance				
(Degrees @ rpm)	0° @ 2100 6° @ 2600 10° @ 3400	0° @ 2100 6° @ 2600 10° @ 3400	0° @ 2200 4° @ 2600 4° @ 3000 8° @ 3400	0° @ 2200 4° @ 2600 4° @ 3000 8° @ 3400
Vacuum Advance				
(Degrees @ Hg Vacuum)	0° @ 2" 25° @ 12"	0° @ 2" 25° @ 12"	0° @ 1" 25° @ 13"	0° @ 1" 25° @ 13"
Speed/Vacuum Limiting Curva				
(Degrees @ rpm)	10° @ 1000 25° @ 1600 18° @ 2000	10° @ 1000 25° @ 1600	8° @ 1000 21° @ 1700 25° @ 2200	8° @ 1000 21° @ 1700 25° @ 2200
Start Transient				
Maximum Advance	8°	8°	8°	5°
Constant Duration(secs	20	20	20	15
Decay Time (secs)	10	10	10	15
Attenuation Break Point #1 (rpm)	1000	1000	1000	2000
Attenuation Break Point #2 (rpm)	1600	1600	1600	3000

* Engine Operates on cold engine timing if engine coolant <49°C
Intake charge <17°C

** See also Figures 26,27 and 28 for graphic display of spark curves.

TABLE 20 (CONT'D)

Notes: Timing Specifications

1. Vacuum and governor advance are additive to basic timing.

2. The vacuum accumulator, or clock function (count-up time, count-down time and zero time offset) scales the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed.

3. Governor and vacuum spark advance curves are essentially linear between the points specified.

4. The"start-to-run" speed is the speed at which the computer switches from crank timing to run (Basic + Governor + Vacuum + Start Transient) timing. The computer reverts back to crank timing if the engine speed falls below the "run-to-start" speed.

TABLE 21

VEHICLE NO. 3 AUTOMATIC IDLE SPEED

BASE VEHICLE SPECIFICATIONS

1. GENERAL

Engine - Displacement	1.7L
- Compression Ratio	8.2:1
Transmission	3 Speed Auto.
Axle Ratio	3.48:1
Carburetor	Holley 5220 Series Chrysler P/N 5214324

2. CARBURETOR SPECIFICATIONS

Idle Speed (rpm)	900
Propane Enriched Idle Speed (rpm)	1000
Hot Fast Idle Speed (rpm)	1700
Vacuum Kick	0.040"
Fast Idle Cam Index	0.040"
Choke Index	2 Notches Rich

* For Detailed Tuneup Procedure See Appendix 2

(...cont'd)

TABLE 21 (Cont'd)

3. ELECTRONIC SPARK ADVANCE SPECIFICATIONS

General

Crank Advance	10
Basic Advance	15
Coolant Sensor (Thermistor Type)	Yes
Vacuum Accumulator (Clock)	Yes
Maximum Advance	55°
Start to Run Speed (rpm)	600
Run to Start Speed (rpm)	300

Governor Advance

(Degrees @ rpm)	0° @ 1000
	10° @ 2000
	20° @ 6000

Cold Vacuum Advance

(Degrees @ Hg Vacuum)	0° Throughout Vacuum Range

Cold/Hot Vacuum Transition (°C)	66°C

Hot Vacuum Advance

(Degrees @ Hg Vacuum)	0° @ 0"
	25° @ 10"

Speed/Vacuum Limiting Curve

(Applies to Hot Vacuum Advance Only)

(Degrees @ rpm)	7° @ 1100
	16° @ 1700
	25° @ 2300

Vacuum Accumulator

(Applies to Hot Vacuum Only)

Zero Time Offset	16%
Count Up Time (secs)	400
Count Down Time (secs)	200

TABLE 21 (CONT'D)

Notes: Timing Specifications

1. Vacuum and governor advance are additive to basic timing.

2. The vacuum accumulator, or clock function (count-up time, count-down time and zero time offset) scales the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed.

3. Governor and vacuum spark advance curves are essentially linear between the points specified.

4. The"start-to-run" speed is the speed at which the computer switches from crank timing to run (Basic + Governor + Vacuum + Start Transient) timing. The computer reverts back to crank timing if the engine speed falls below the "run-to-start" speed.

TABLE 22

VEHICLE NC. 3 AUTOMATIC IDLE SPEED

MODIFIED VEHICLE SPECIFICATIONS

1. GENERAL

Engine - Displacement	1.7L
- Compression Ratio	8.2:1
Transmission	3 Speed Auto
Axle Ratio	3.48:1
Carburetor	Holley 5220 Series Chrysler P/N 5214324

2. CARBURETOR SPECIFICATIONS

Idle Speed (rpm)	850 Neutral/700 Drive
Propane Enriched Idle Speed (rpm)	See Vehicle Tuneup Procedures in Appendix 2 and service prom specifications in Appendix 14
Hot Fast Idle Speed (rpm)	
Vacuum Kick	
Fast Idle Cam Index	
Choke Index	2 Notches Rich

(...cont'd)

TABLE 22 (Cont'd)

3. ELECTRONIC SPARK ADVANCE SPECIFICATIONS

	CALIBRATION			
	PROM A	PROM A-1	PROM A-1'	PROM A-2
General				
Crank Advance	10	10	10	10
Basic Advance	15	15	15	15
Coolant Sensor (Thermistor Type)	Yes	Yes	Yes	Yes
Vacuum Accumulator (Clock)	Yes	Yes	Yes	Yes
Maximum Advance	55°	55°	55°	55°
Start To Run Speed (rpm)	900	900	900	800
Run To Start Speed (rpm)	200	200	200	200
Governor Advance				
(Degrees @ rpm)	0° @ 1000 10° @ 2000 20° @ 6000	0° @ 1000 10° @ 2000 20° @ 6000	0° @ 1000 10° @ 2000 20° @ 6000	0° @ 1000 10° @ 2000 20° @ 6000
Cold Vacuum Advance				
(Degrees @ Hg Vacuum)	20° @ 0" 20° @ 8" 0° @ 15"	15° @ 0" 15° @ 3" 0° @ 15"	15° @ 0" 15° @ 3" 0° @ 15"	15° @ 0" 15° @ 5" 0° @ 17"
Cold/Hot Vacuum Transition (°C)	66°	66°	66°	66°
Hot Vacuum Advance				
(Degrees @ Hg Vacuum)	0° @ 0" 25° @ 10"	0° @ 0" 25° @ 10"	0° @ 0" 25° @ 10"	0° @ 0" 25° @ 10"
Speed/Vacuum Limiting Curve (Applies to Hot Vacuum Advance Only)				
(Degrees @ rpm)	7° @ 1100 16° @ 1700 25° @ 2300	7° @ 1100 16° @ 1700 25° @ 2300	7° @ 1100 16° @ 1700 25° @ 2300	7° @ 1100 16° @ 1700 25° @ 2300
Vacuum Accumulator (Applies to Hot Vacuum Only)				
Zero Time Offset	16%	16%	16%	16%
Count Up Time (secs)	400	400	400	400
Count Down Time (secs)	200	200	200	200

(...cont'd)

TABLE 22 (Cont'd)

	CALIBRATION			
	PROM A	PROM A-1	PROM A-1'	PROM A-2
Automatic Idle Speed				
Idle Speed Range (rpm)	±5	±5	±5	±5
(rpm @°C Coolant Temp.) Drive	1100 @ 21 700 @ 66	1200 @ -1 700 @ 66	1200 @ -1 700 @ 66	1300 @ -7 700 @ 66
Neutral	1100 @ 21 800 @ 54	1200 @ -1 850 @ 43	1200 @ -1 850 @ 43	1300 @ -7 850 @ 43
Hot Start rpm (Drive) (rpm for seconds)	800 for 10	850 for 10	850 for 10	850 for 10
Throttle Kick rpm(Drive) (rpm for Seconds)	750 for 1	800 for 10	850 for 10	800 for 10
Decel control Speed (rpm)	1200	1200	800	780
Cold Start Kick Temp. (°C)	38	38	38	38

Notes: Timing Specifications

1. Vacuum and governor advance are additive to basic timing.

2. The vacuum accumulator, or clock function (count-up time, count-down time and zero time offset) scales the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed.

3. Governor and vacuum spark advance curves are essentially linear between the points specified.

4. The "start-to-run" speed is the speed at which the computer switches from crank timing to run (Basic + Governor + Vacuum + Start Transient) timing. The computer reverts back to crank timing if the engine speed falls below the "run-to-start" speed.

TABLE 23

VEHICLE NO. 9 PROPANE

CALIBRATION A AND B SPECIFICATIONS

1. GENERAL

Engine - Displacement	1.7L
- Compression Ratio	9.3:1
Transmission	3 Speed Auto
Axle Ratio	3.48:1
Carburetor	IMPCO MODEL 125

2. CARBURETOR SPECIFICATIONS *

Idle Speed (rpm)	900
Idle Co (%)	1.0
Hot Fast Idle Speed (rpm)	1700

* For Detailed Tuneup Procedure See Appendix 2

3. ELECTRONIC SPARK ADVANCE

	CALIBRATION A AND B	
	PROM AP1	PROM 2PB
General		
Crank Advance	10°	10°
Basic Advance	20°	20°
Coolant Switch	N/A	N/A
Vacuum Accumulator (Clock)	No	No
Maximum Advance	45°	45°
Start to Run Speed (rpm)	900	900
Run to Start Speed (rpm)	200	200

(...cont'd)

TABLE 23 (Cont'd)

	CALIBRATION A AND B	
	PROM AP1	PROM 2PB
Governor Advance		
(Degrees @ rpm)	0° @ 1000	0° @ 1000
	4° @ 1500	4° @ 1500
	10° @ 4000	10° @ 4000
Vacuum Advance		
(Degrees @ in Hg Vacuum)	0° @ 2"	0° @ 2"
	12° @ 7"	12° @ 20"
Speed/Vacuum Limiting Curve		
(Degrees @ rpm)	12° @ 1500	12° @ 1500
	6° @ 4000	6° @ 4000

Notes: Timing Specifications

1. Vacuum and governor advance are additive to basic timing.
2. The vacuum accumulator, or clock function (count-up time, count-down time and zero time offset) scales the vacuum advance curve. The clock function acts directly on the vacuum advance curve and provides a percentage of vacuum advance available depending on how long the carb idle contact switch has remained open or closed.
3. Governor and vacuum spark advance curves are essentially linear between the points specified.
4. The"start-to-run" speed is the speed at which the computer switches from crank timing to run (Basic + Governor + Vacuum + Start Transient) timing. The computer reverts back to crank timing if the engine speed falls below the "run-to-start" speed.

TEST NUMBER	CONFIGURATION	TEST TEMPERATURE °C	AVERAGE FUEL CONSUMPTION LITRES/100 KM * (mi/US gal.)				
			BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
1.1.2	Base Vehicle	+25	9.50 (24.76)	7.87 (29.89)	7.99 (29.44)	8.24 (28.55)	6.24 (37.70)
1.2.2	With Optimum Cold Timing (OCT)		9.04 (26.02)	7.98 (29.48)	7.89 (29.81)	8.18 (28.76)	6.28 (37.46)
1.1.3	Base Vehicle	0	12.74 (18.46)	8.82 (26.67)	8.62 (27.29)	9.58 (24.55)	6.82 (34.49)
1.2.3	With OCT		12.23 (19.23)	8.78 (26.79)	8.60 (27.35)	9.45 (24.89)	6.83 (34.44)
1.1.4	Base Vehicle	-20	17.55 (13.40)	9.86 (23.86)	10.29 (22.86)	11.55 (20.37)	7.31 (32.18)
1.2.4	With OCT		17.14 (13.72)	9.92 (23.71)	9.69 (24.27)	11.35 (20.72)	7.39 (31.83)

Table 24 - Average Fuel Consumption Data for Optimum Cold Timing Configuration (Vehicle 1)

* Fuel consumption determined by gravimetric methods

TEST NUMBER	CONFIGURATION	TEST TEMPERATURE °C	AVERAGE FUEL CONSUMPTION LITRES/100 KM * (mi/US gal.)				
			BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
3.1.2	Base Vehicle	+25	9.94 (23.66)	8.49 (27.71)	8.36 (28.14)	8.75 (26.88)	6.32 (37.22)
3.2.2	With Automatic Idle Speed Control (AIS)		9.88 (23.81)	8.66 (27.16)	8.43 (27.90)	8.95 (26.58)	6.30 (37.34)
3.1.3	Base Vehicle	0	12.43 (18.92)	9.36 (25.13)	9.03 (26.05)	9.91 (23.74)	6.95 (33.84)
3.2.3	With AIS		12.20 (19.28)	9.78 (24.05)	9.14 (25.74)	10.10 (23.29)	7.04 (33.41)
3.1.4	Base Vehicle	-20	18.95 (12.41)	10.01 (23.50)	10.59 (22.21)	12.01 (19.59)	7.62 (30.87)
3.2.4	With AIS		16.65 (14.13)	10.33 (22.77)	10.24 (22.97)	11.61 (20.26)	7.65 (30.75)

Table 25 - Average Fuel Consumption Data for Automatic Idle Speed Configuration (Vehicle 3)

* Fuel consumption determined by gravimetric methods

TEST NUMBER	CONFIGURATION	TEST TEMPERATURE °C	AVERAGE FUEL CONSUMPTION LITRES/100 KM* (mi/US gal.)				
			BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
9.1.2	Calibration A	+25	10.94 (21.50)	10.21 (23.04)	10.01 (23.50)	10.30 (22.84)	8.82 (26.67)
9.2.2	Calibration B		11.64 (20.21)	10.56 (22.27)	10.31 (22.81)	10.72 (21.94)	8.96 (26.25)
9.1.3	A	0	13.53 (17.39)	11.08 (21.23)	10.98 (21.42)	11.56 (20.35)	9.20 (25.57)
9.2.3	B		12.30 (19.12)	10.59 (22.21)	10.52 (22.36)	10.93 (21.52)	8.94 (26.31)
9.1.4	A	-20	17.37 (13.54)	12.32 (19.09)	12.55 (18.74)	13.44 (17.50)	9.70 (24.25)
9.1.4B	A with 2 hr Blockheat		15.06 (15.62)	11.71 (20.09)	11.73 (20.05)	12.40 (18.97)	9.91 (23,74)
9.1.4C**	A with 2 hr Blockheat and Heated Air Intake		15.36 (15.31)	11.68 (20.14)	11.80 (19.93)	12.48 (18.85)	10.05 (23.40)
9.2.4	B		16.95 (13.88)	11.83 (19.88)	12.11 (19.42)	12.96 (18.15)	10.06 (23.38)
9.1.5**	A with 5 hr Blockheat	-35	18.50 (12.71)	14.15 (16.62)	12.03 (19.55)	14.44 (16.29)	10.49 (22.42)

Table 26 - Average Fuel Consumption Data for Propane Configuration (Vehicle #9)

* Fuel consumption determined by carbon balance methods

** Represents one run only

TEST TEMP.		+25°C		0°C		-20°C	
TEST NUMBER		1.1.2	1.2.2	1.1.3	1.2.3	1.1.4	1.2.4
CONFIGURATION		BASE	O.C.T.	BASE	O.C.T.	BASE	O.C.T.
EMISSIONS	(g/mi)						
BAG 1	HC	1.67	1.97	2.50	3.26	6.24	8.42
	NOx	3.60	3.63	3.42	3.66	2.24	3.26
	CO	12.33	12.37	43.4	47.26	98.82	102.8
	CO_2	292.7	271.6	309.3	327.1	425.8	354.1
BAG 2	HC	1.74	1.75	1.78	1.77	2.14	2.23
	NOx	3.02	3.10	3.81	3.67	3.79	3.73
	CO	5.97	6.73	7.71	7.98	16.63	18.2
	CO_2	253.4	254.5	286.8	286.2	315.3	309.7
BAG 3	HC	1.64	1.60	1.58	1.58	1.86	2.09
	NOx	4.13	4.15	4.77	4.76	4.64	4.76
	CO	5.62	6.16	6.31	6.20	19.34	18.71
	CO_2	256.5	253.4	278.4	283.4	331.8	306.2
COMPOSITE CITY CYCLE	HC	1.70	1.75	1.88	2.02	2.91	3.47
	NOx	3.45	3.50	3.99	3.97	3.70	3.91
	CO	7.19	7.74	14.72	15.62	34.41	35.79
	CO_2	262.4	257.7	289.1	293.9	342.7	317.9
HIGHWAY CYCLE	HC	0.96	0.96	1.08	1.06	1.14	1.18
	NOx	4.36	4.49	4.95	4.99	5.31	5.36
	CO	3.76	3.84	2.42	2.87	2.74	2.62
	CO_2	220.5	212.8	233.4	240.1	252.7	246.3

Table 27 - Average Exhaust Emissions Data for Optimum Cold Timing Configuration (Vehicle 1)

TEST TEMPERATURE		+25°C		0°C		-20°C	
TEST NUMBER		3.1.2	3.2.2	3.1.3	3.2.3	3.1.4	3.2.4
CONFIGURATION		BASE	A.I.S.	BASE	A.I.S.	BASE	A.I.S.
EMISSIONS	(g/mi)						
BAG 1	HC	4.93	1.16	2.45	1.80	10.12	4.57
	NO_x	2.33	2.55	2.86	2.98	1.88	2.76
	CO	16.26	15.97	38.80	34.53	111.2	92.48
	CO_2	319.8	311.0	354.6	331.2	436.6	379.1
BAG 2	HC	1.23	1.09	1.18	1.10	1.27	1.28
	NO_x	2.13	2.01	2.56	2.24	2.59	2.45
	CO	4.52	9.01	7.39	10.42	14.32	13.93
	CO_2	283.6	285.6	308.6	309.7	322.1	334.4
BAG 3	HC	0.92	0.92	0.93	0.86	1.18	1.12
	NO_x	2.56	2.53	3.16	2.94	2.73	3.28
	CO	3.07	4.58	4.09	6.13	12.66	11.06
	CO_2	272.2	280.0	302.6	316.2	353.4	345.6
COMPOSITE CITY CYCLE	HC	1.91	1.06	1.37	1.18	3.07	1.92
	NO_x	2.29	2.26	2.79	2.59	2.48	2.74
	CO	6.55	9.23	13.00	14.24	33.85	29.39
	CO_2	288.0	289.3	316.5	315.9	354.3	346.8
HIGHWAY CYCLE	HC	0.62	0.62	0.71	0.67	0.79	0.78
	NO_x	4.40	3.90	4.43	4.30	5.41	4.89
	CO	2.21	2.01	1.69	1.84	1.76	2.09
	CO_2	219.2	219.2	241.8	252.1	282.4	276.6

Table 28 - Average Exhaust Emissions Data For Automatic Idle Speed Control Configuration (Vehicle 3)

TEST TEMPERATURE		+25°C		0°C		-20°C				-35°C
TEST NUMBER		9.1.2	9.2.2	9.1.3	9.2.3	9.1.4	9.2.4	9.1.4B	9.1.4C*	9.1.5-3*
CALIBRATION		A	B	A	B	A	B			
EMISSIONS (g/mi)										
BAG 1	HC	1.52	1.42	1.13	1.11	8.02	5.43	1.33	1.31	1.58
	NO_x	3.24	3.58	4.79	4.87	5.36	5.44	5.41	5.70	5.23
	CO	4.58	4.68	5.53	2.78	27.0	23.52	12.44	8.56	22.48
	CO_2	254.3	271.8	317.4	291.6	355.1	358.7	343.0	356.6	410.4
BAG 2	HC	1.16	1.16	1.18	1.16	2.58	1.38	1.36	1.32	1.46
	NO_x	2.93	2.99	3.54	3.68	3.77	4.09	3.99	3.99	3.30
	CO	11.62	8.79	10.09	4.62	22.1	11.04	7.49	4.28	27.14
	CO_2	226.6	239.8	250.3	247.1	257.2	266.5	269.0	273.5	297.3
BAG 3	HC	0.87	0.84	0.93	0.91	1.08	1.16	1.00	1.02	1.72
	NO_x	3.79	3.75	4.37	4.50	5.07	4.89	4.79	5.18	3.81
	CO	4.56	3.63	5.34	2.49	3.97	5.3	3.84	2.59	10.37
	CO_2	233.7	242.8	256.0	249.6	297.0	283.1	276.4	280.3	271.2
COMPOSITE CITY CYCLE	HC	1.15	1.13	1.10	1.08	3.30	2.15	1.25	1.24	1.55
	NO_x	3.23	3.32	4.02	4.15	4.46	4.59	4.50	4.67	3.83
	CO	8.22	6.52	7.84	3.65	18.14	12.02	7.51	4.70	21.59
	CO_2	234.4	247.2	265.8	257.0	288.4	289.9	286.3	292.6	313.0
HIGHWAY CYCLE	HC	0.44	0.42	0.45	0.46	0.53	0.54	0.50	0.53	0.63
	NO_x	3.48	3.61	3.63	3.44	3.51	3.97	3.67	4.44	2.67
	CO	1.20	1.25	1.44	1.19	1.16	1.35	1.23	1.04	1.73
	CO_2	211.5	214.9	220.4	214.3	232.8	241.1	237.8	241.5	250.9

Table 29 - Average Exhaust Emissions Data For Propane Configuration (Vehicle 9)

Note - * Indicates one run only performed.

TEST #	CONFIGURATION	SID RATINGS											WEATHER CONDITIONS				
		COLD START	COLD IDLE	COLD DRIVE	WARM IDLE	WARM DRIVE	HOT START	HOT IDLE	HOT DRIVE	P.C.D. + START	P.C.D. + IDLE	P.C.D. + DRIVE	OVERNIGHT LOW TEMP. (°C)	TEST TEMP. (°C)	% RELATIVE HUMIDITY	SOAK TIME (hrs)	BAROMETER kPa
1.1.1-1	BASE	8	6½	7	7	8	9	7	7½	9	7	7½	+2	+2	75	18	98.95
1.1.1-2	BASE	7*	7	7	7	8	9	7	7½	9	7	7½	-9	-7	53	18½	101.36
1.2.1-1	O.C.T.	9	7	8	7	8	9	7	8	9	7	7	0	+2	64	17½	101.80
1.2.1-2	O.C.T.	7*	6	8	7	8	9	7	8	9	7	8	+1	+4	100	18½	99.98
3.1.1-1	BASE	6*	7	7	8	8	9	7	7½	9	7	7½	+2	+2	75	17¼	98.95
3.1.1-2	BASE	7	7	7	7	8	9	7	7	9	7	7	-9	-7	53	20¾	101.36
3.2.1-1	A.I.S.	8	7	6½	7	7	9	7	7	9	7	7	0	2	64	17	101.80
3.2.1-2	A.I.S.	3*	7	7	7	8	9	7	8	9	7	7½	+1	+4	100	22¾	99.98
9.1.1-1	'A'	8	5	8	4	7	9	5	7	9	6	8	-5	+1	87	16	10 .60
9.1.1-2	'A'	7	5½	7	6	8							-6	-2	40	18	103.20
9.2.1-1	'B'	7	6	7½	6½	8	9	7	7½	9	7	8	-9	-5	53	18	101.36

+ P.C.D. = Partial Cool Down

* Indicates Dieout

TABLE 30 - Summary of Driveability SID Ratings

TEST NO	CONFIGURATION	TEST TEMP. °C	AVERAGE FUEL CONSUMPTION LITRES/100 KM*				
			BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
1A4	Modified - Calibration A	-20	20.52	10.59	10.70	12.68	7.68
1B4	Modified - Calibration B	-20	19.59	10.06	10.40	12.13	7.57
1C4	Modified - Calibration C	-20	19.42	10.53	10.58	12.39	7.60

Table 31 - Average Fuel Consumption Data for Optimum Cold Timing Configuration (Vehicle 1) Preliminary Tests

* Fuel Consumption determined by gravimetric methods.

TEST TEMP. °C	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION				
	BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
+25	4.8	-1.4	1.3	0.7	-0.6
0	4.0	0.5	0.2	1.4	-0.1
-20	2.3	-0.6	5.8	1.7	-1.1

Table 32 - Improvement in Fuel Consumption Over Baseline For Optimum Cold Timing Vehicle
(Based on data from Table 24)

		Average % Difference in Exhaust Emissions over Baseline		
TEST TEMPERATURE °C		+25	0	-20
Bag 1	HC	18.0	30.4	34.9
	NO_x	0.8	7.0	45.5
	CO	0.3	8.9	4.0
	CO_2	-7.2	5.8	-16.8
Bag 2	HC	0.6	-0.6	4.2
	NO_x	2.6	-3.7	-1.6
	CO	12.7	3.5	9.4
	CO_2	0.4	-0.2	-1.8
Bag 3	HC	-2.4	0.0	12.3
	NO_x	0.5	-0.2	2.6
	CO	9.6	-1.7	-3.3
	CO_2	-1.2	1.8	-7.7
Composite City Cycle	HC	2.9	7.4	19.2
	NO_x	1.5	-0.5	5.7
	CO	7.6	6.1	4.0
	CO_2	-1.8	1.7	-7.2
Highway Cycle	HC	0.0	-1.9	3.5
	NO_x	3.0	0.8	0.9
	CO	2.1	18.6	-4.4
	CO_2	-3.5	2.9	-2.5

Based on Data from Table 27

Table 33 - Modified versus Baseline Exhaust
Emissions Comparison
Optimum Cold Timing Configuration (Vehicle #1)

TEST TEMP. °C	AVERAGE % IMPROVEMENT IN FUEL CONSUMPTION				
	BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
+25	0.6	-2.0	-0.8	-1.1	0.3
0	1.9	-4.5	-1.2	-1.9	-1.3
-20	12.1	-3.2	3.3	3.3	-0.4

Table 34 - Improvement in Fuel Consumption over Baseline For Automatic Idle Speed Vehicle
(Based on Data from Table 25)

		Average % Difference in Exhaust Emissions over Baseline		
TEST TEMPERATURE °C		+25	0	-20
Bag 1	HC	-74.5	-26.5	-54.8
	NO_x	9.4	4.2	46.8
	CO	-1.8	-11.0	-16.8
	CO_2	-2.8	- 6.6	-13.2
Bag 2	HC	-11.4	-6.8	0.8
	NO_x	- 5.6	-12.5	-5.4
	CO	99.3	41.0	- 2.8
	CO_2	0.7	0.4	3.8
Bag 3	HC	0.0	-7.5	-5.1
	NO_x	-1.2	-7.0	20.1
	CO	49.2	49.9	-12.6
	CO_2	2.9	4.5	-2.2
Composite City Cycle	HC	-44.5	-13.9	-37.5
	NO_x	-1.3	-7.2	10.5
	CO	40.9	9.5	-13.1
	CO_2	0.5	-0.2	-2.1
Highway Cycle	HC	0.0	-5.6	-1.3
	NO_x	-11.4	-2.9	-9.6
	CO	-9.0	8.9	18.8
	CO_2	0.0	4.3	-2.1

Based on Data from Table 28

Table 35 - Modified versus Baseline Exhaust Emissions Comparison-Automatic Idle Speed Configuration Vehicle #3

TEST TEMP. °C	AVERAGE % DIFFERENCE IN FUEL CONSUMPTION				
	BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
+25	+6.4	+3.4	+3.0	+4.1	+1.6
0	-9.1	-4.4	-4.2	-5.4	-2.8
-20	-2.4	-4.0	-3.5	-3.6	+3.7

Table 36 - Difference in Fuel Consumption of Calibration B versus Calibration A for Propane Car (Vehicle #9) (Based on Data from Table 26)

TEST TEMPERATURE °C		Average % Difference in Exhaust Emissions Calibration B over Calibration A		
		+25	0	-20
Bag 1	HC	- 6.6	- 1.8	-32.3
	NO_x	10.5	1.7	1.5
	CO	2.2	-49.7	-12.9
	CO_2	6.9	- 8.1	1.0
Bag 2	HC	0.0	- 1.7	-46.5
	NO_x	2.0	4.0	8.5
	CO	-24.4	-54.2	-50.0
	CO_2	5.8	- 1.3	3.6
Bag 3	HC	- 3.4	- 2.2	7.4
	NO_x	- 1.1	3.0	- 3.6
	CO	-20.4	-53.4	33.5
	CO_2	3.9	- 2.5	- 4.7
Composite City Cycle	HC	- 1.7	- 1.8	-34.8
	NO_x	2.8	3.2	2.9
	CO	-20.7	-53.4	-33.7
	CO_2	5.5	-3.3	0.5
Highway Cycle	HC	- 4.5	2.2	1.9
	NO_x	3.7	- 5.2	13.1
	CO	4.2	-17.4	16.4
	CO_2	1.6	- 2.8	3.6

Based on Data from Table 29

Table 37 - Calibration B versus Calibration A
Exhaust Emissions Comparison
Propane Configuration Vehicle #9

TEST #	CONFIGURATION	TEST TEMP. °C	AVERAGE FUEL CONSUMPTION L/100 km CARBON BALANCE RESULTS				
			BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
3.1.2	Base Vehicle	25	9.58	7.82	7.43	8.08	5.98
3.1.3	Base Vehicle	0	11.23	8.60	8.28	9.06	6.55
3.1.4	Base Vehicle	-20	17.08	9.25	10.00	11.07	7.64

Table 38 - Average Fuel Consumption Data From Carbon Balance Results - Vehicle 3 Base Configuration

TEST TEMP. °C	AVERAGE % DIFFERENCE IN FUEL CONSUMPTION-PROPANE VS GASOLINE				
	BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
+25	+21.5	+35.0	+38.8	+32.7	+49.8
0	+9.5	+23.1	+27.1	+20.6	+36.5
-20	-0.8	+27.9	+21.1	+17.1	+31.7

Based on Data from Tables 26 and 38

Table 39 - Propane to Gasoline Fuel Consumption Comparison Vehicle No. 9 Calibration B vs. Vehicle #3 in Base Configuration
(Comparison based on Fuel Consumption calculated using Carbon Balance Methods for both vehicles)

TEST NUMBER	AVERAGE % INCREASE IN FUEL CONSUMPTION					
	CITY			HIGHWAY		
	+25°C	0°C	-20°C	+25°C	0°C	-20°C
1.1 O.C.T. Base Vehicle	Baseline	16.3	40.2	Baseline	9.3	17.1
1.2 O.C.T. Modified Vehicle	Baseline	15.5	38.8	Baseline	8.8	17.7
3.1 A.I.S. Base Vehicle	Baseline	13.2	37.2	Baseline	10.1	20.6
3.2 A.I.S. Modified Vehicle	Baseline	14.2	31.2	Baseline	11.7	21.5
9.1* Propane Cal. A except 4B,4C & 5	Baseline	12.2	30.5	Baseline	4.3	10.0
9.2* Propane Cal. B	Baseline	2.0	20.9	Baseline	-0.2	12.3

Based on Data from Tables 24,25 and 26

Table 40 - Increase in Fuel Consumption
With Temperature For All Vehicles

* Fuel Consumption for Vehicle #9 calculated using Carbon Balance Methods, all others calculated using gravimetric methods.

TEST TEMP. °C	AVERAGE % DIFFERENCE IN FUEL CONSUMPTION CARBON BALANCE RESULTS OVER GRAVIMETRIC RESULTS				
	BAG 1	BAG 2	BAG 3	CITY	HIGHWAY
+25	-3.6	-7.9	-11.1	-7.7	-5.4
0	-9.7	-8.1	- 8.3	-8.6	-5.8
-20	-9.9	-7.6	- 5.6	-7.8	0.3

Based on Data from Tables 25 and 38

Table 41 - Carbon Balance versus Gravimetric
Fuel Consumption Results Comparison
Vehicle #3 Base Configuration

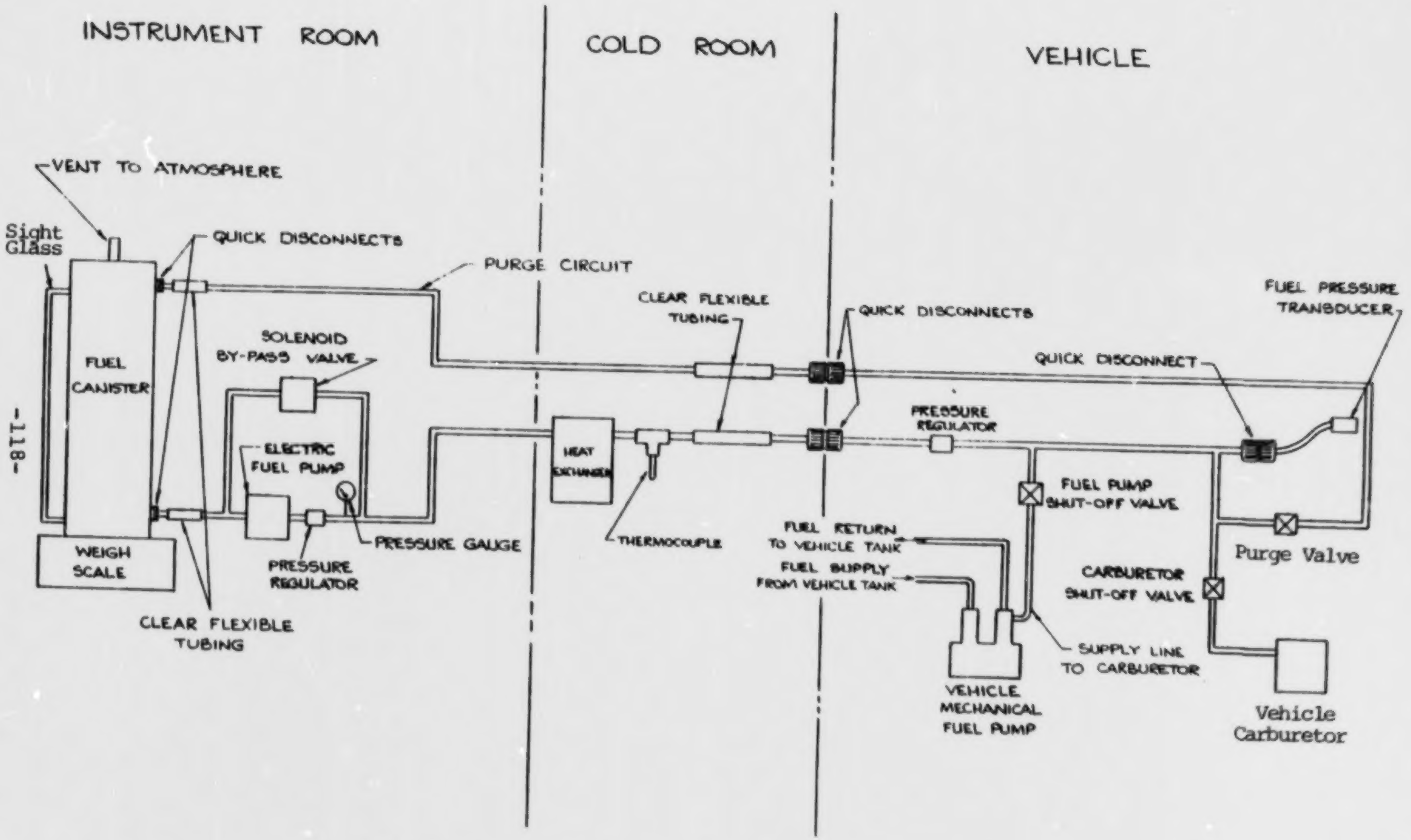

INSTRUMENT ROOM
COLD ROOM
VEHICLE
VENT TO ATMOSPHERE
Sight Glass
QUICK DISCONNECTS
PURGE CIRCUIT
FUEL CANISTER
SOLENOID BY-PASS VALVE
ELECTRIC FUEL PUMP
PRESSURE GAUGE
PRESSURE REGULATOR
WEIGH SCALE
CLEAR FLEXIBLE TUBING
HEAT EXCHANGER
THERMOCOUPLE
CLEAR FLEXIBLE TUBING
QUICK DISCONNECTS
QUICK DISCONNECT
FUEL PRESSURE TRANSDUCER
PRESSURE REGULATOR
FUEL PUMP SHUT-OFF VALVE
FUEL RETURN TO VEHICLE TANK
FUEL SUPPLY FROM VEHICLE TANK
Purge Valve
CARBURETOR SHUT-OFF VALVE
SUPPLY LINE TO CARBURETOR
VEHICLE MECHANICAL FUEL PUMP
Vehicle Carburetor

Figure 1 - Gravimetric Fuel Consumption System

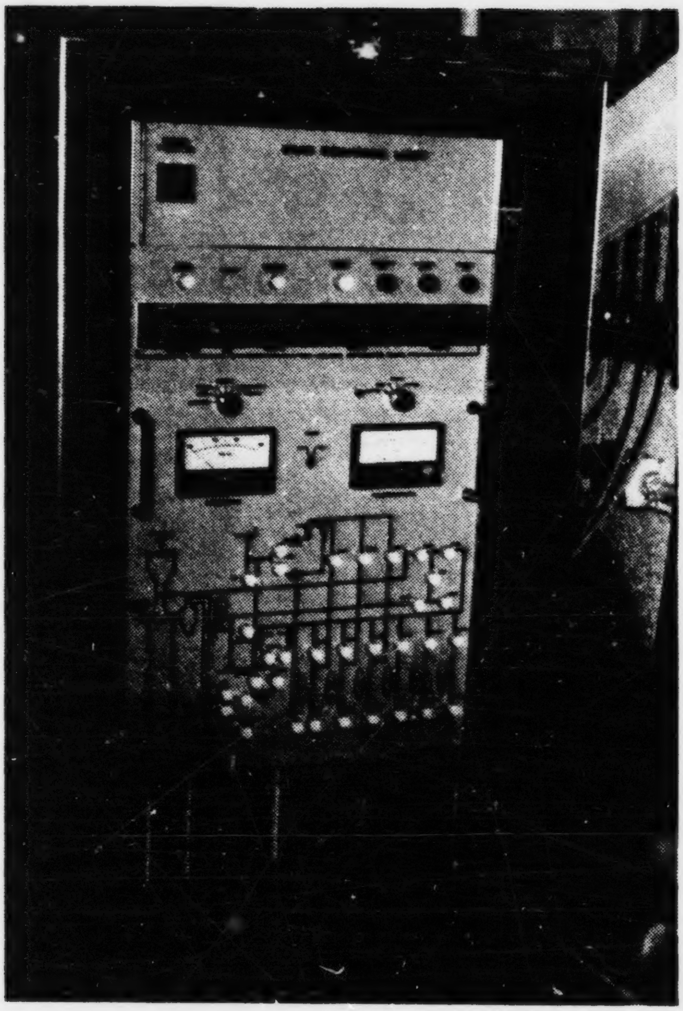


Figure 2 - Exhaust Emissions Sampling System - Control Unit

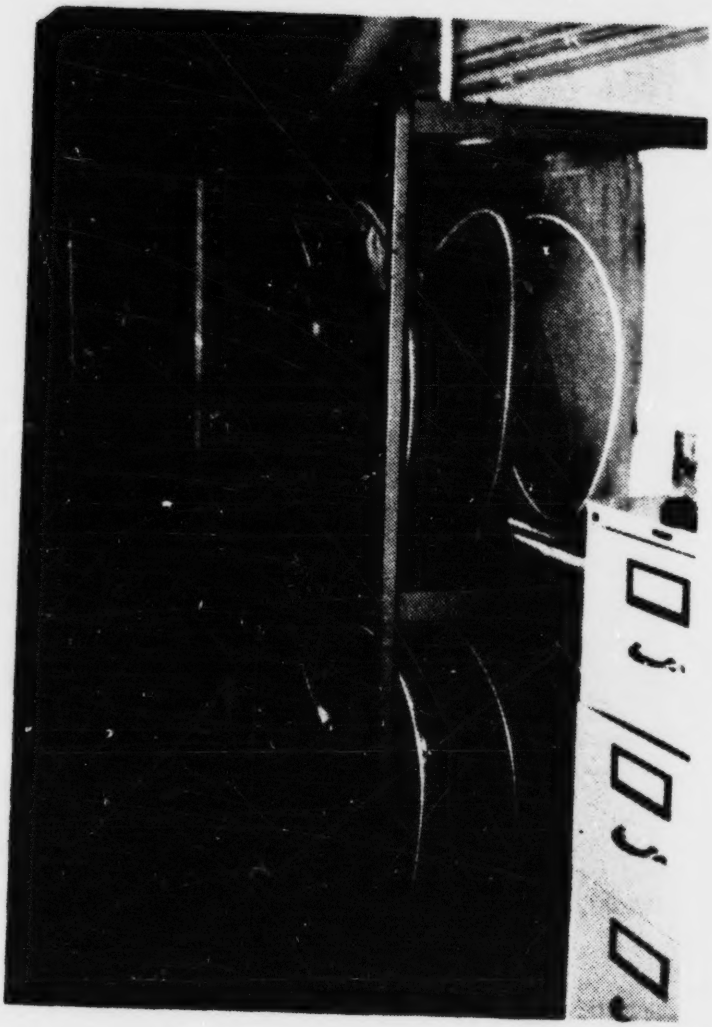


Figure 3 - Exhaust Emissions Sample Storage Bags

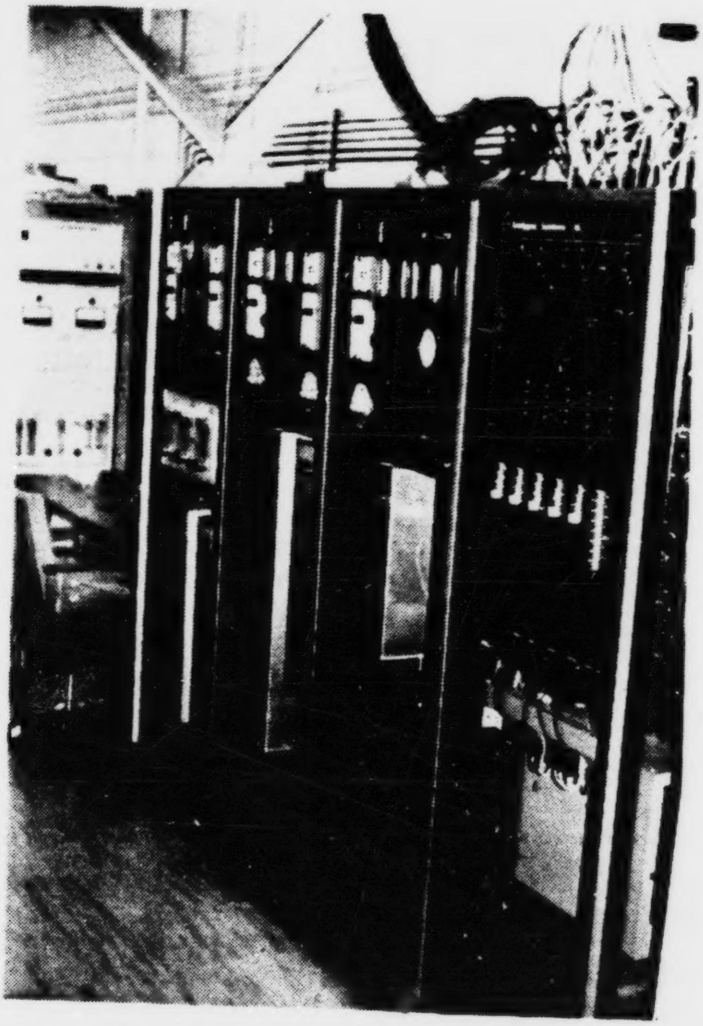


Figure 4 - Exhaust Emissions Analysis Unit

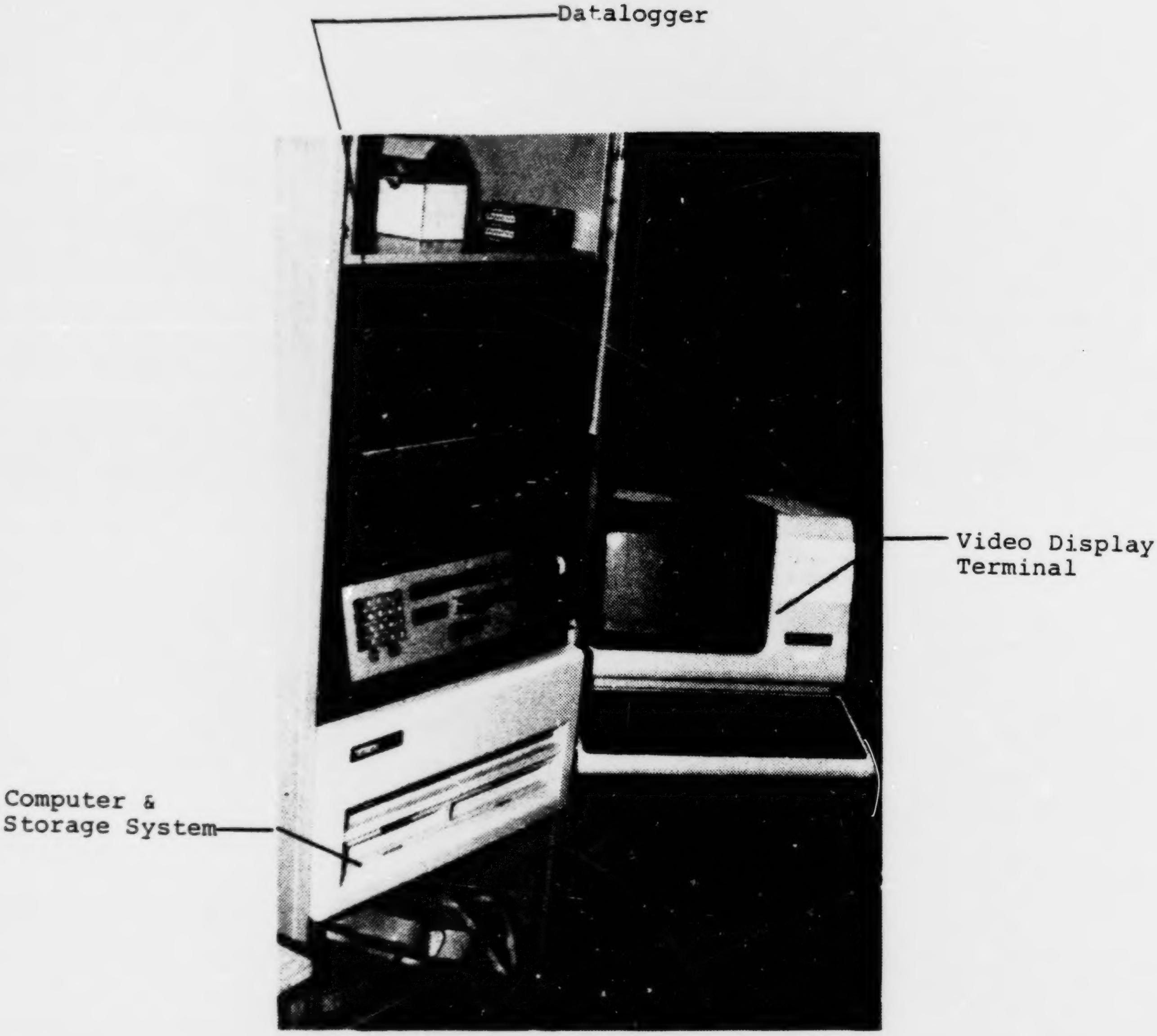

Datalogger
Video Display Terminal
Computer & Storage System

Figure 5 - Instrumentation - Datalogger, Computer & Storage System, and Video Display Terminal

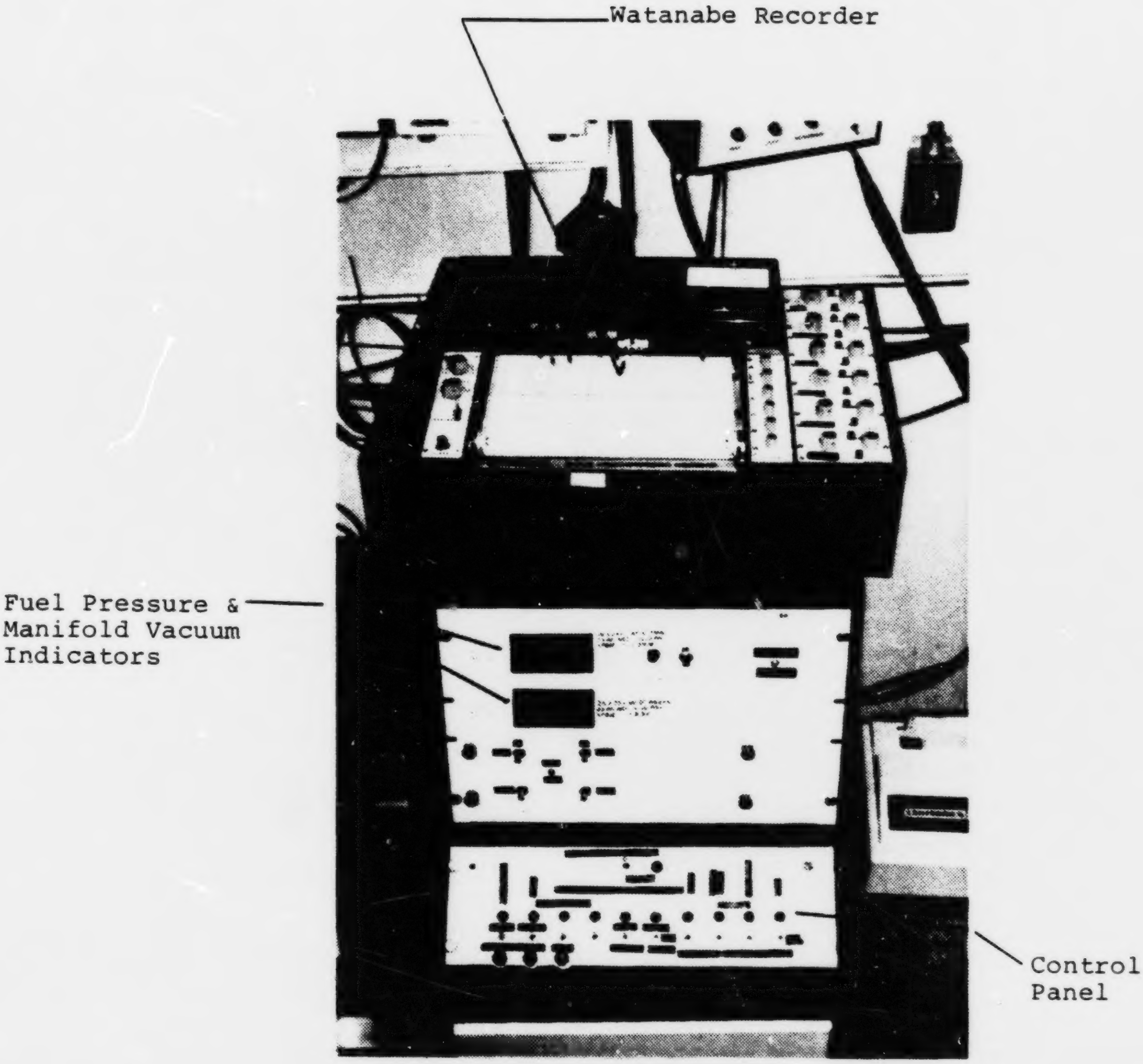

Watanabe Recorder
Fuel Pressure & Manifold Vacuum Indicators
Control Panel

Figure 6 - Instrumentation - Watanabe Recorder, Fuel Pressure & Manifold Vacuum Indicators, & Control Panel

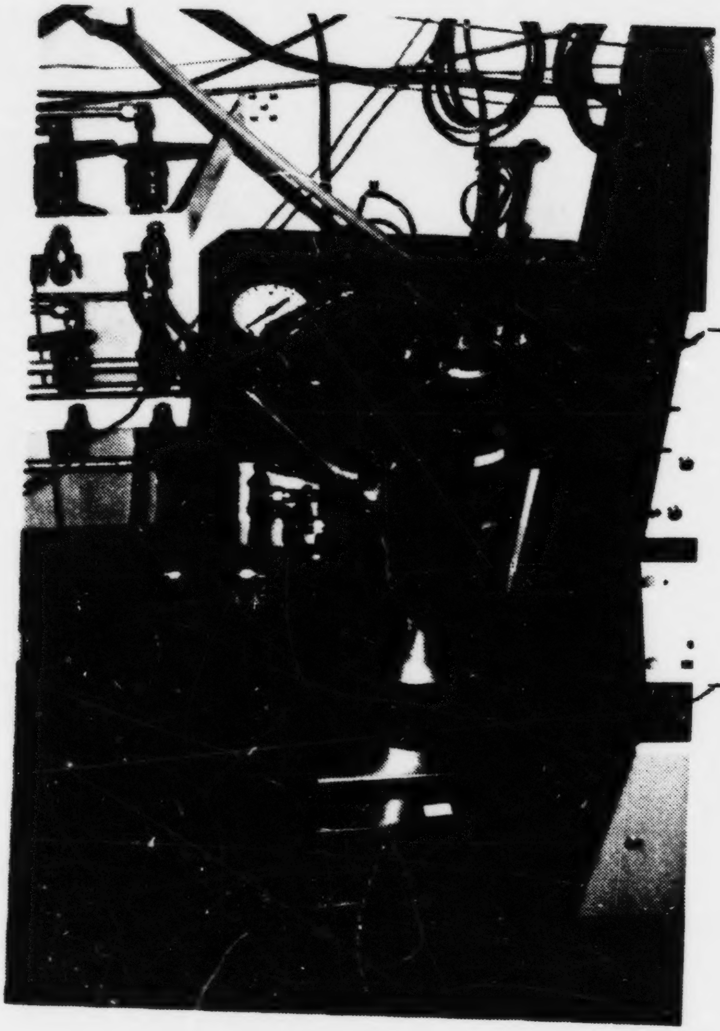

Fuel Cannister
Weigh Scale

Figure 7 - Instrumentation - Fuel Cannister & Weigh Scale

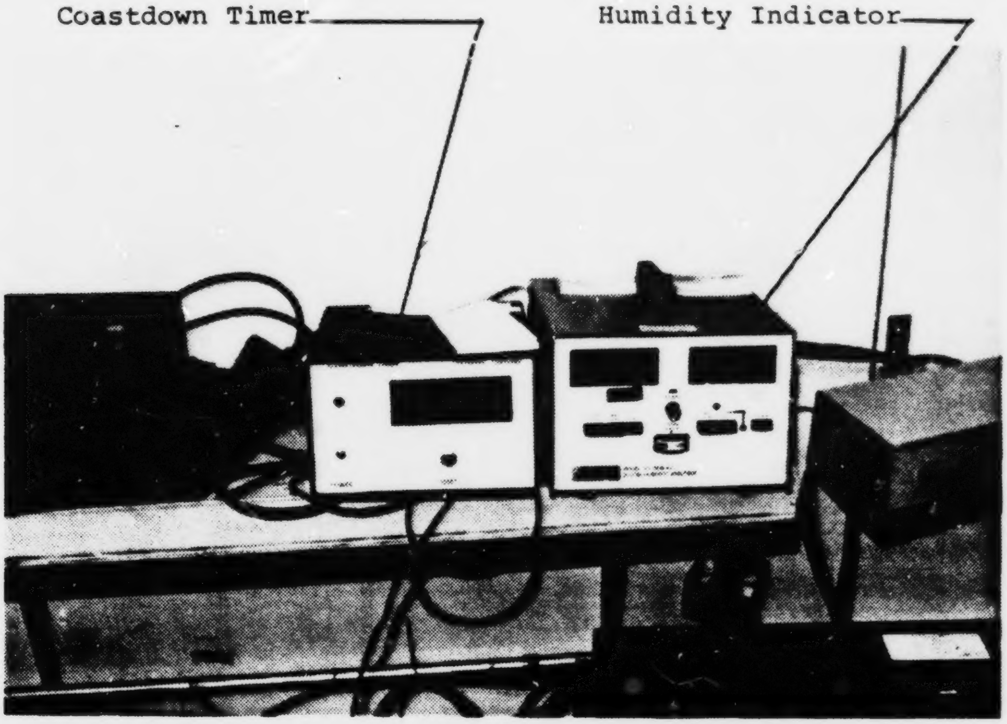

Coastdown Timer
Humidity Indicator

Figure 8 - Instrumentation - Coastdown Timer & Relative Humidity Indicator

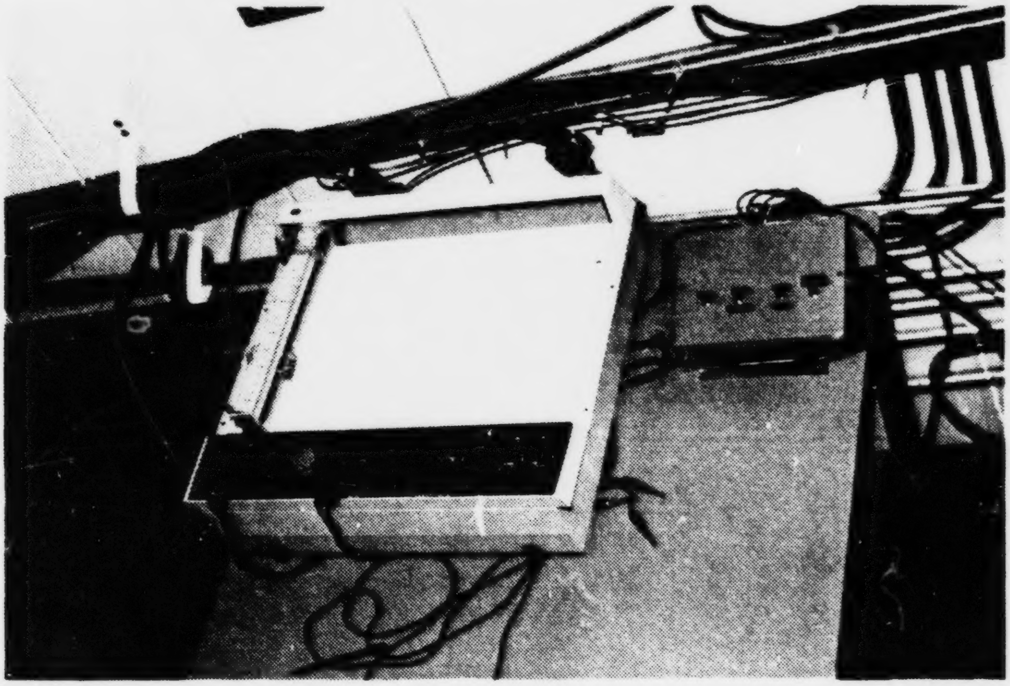


Figure 9 - XY Plotter & Signal Controls

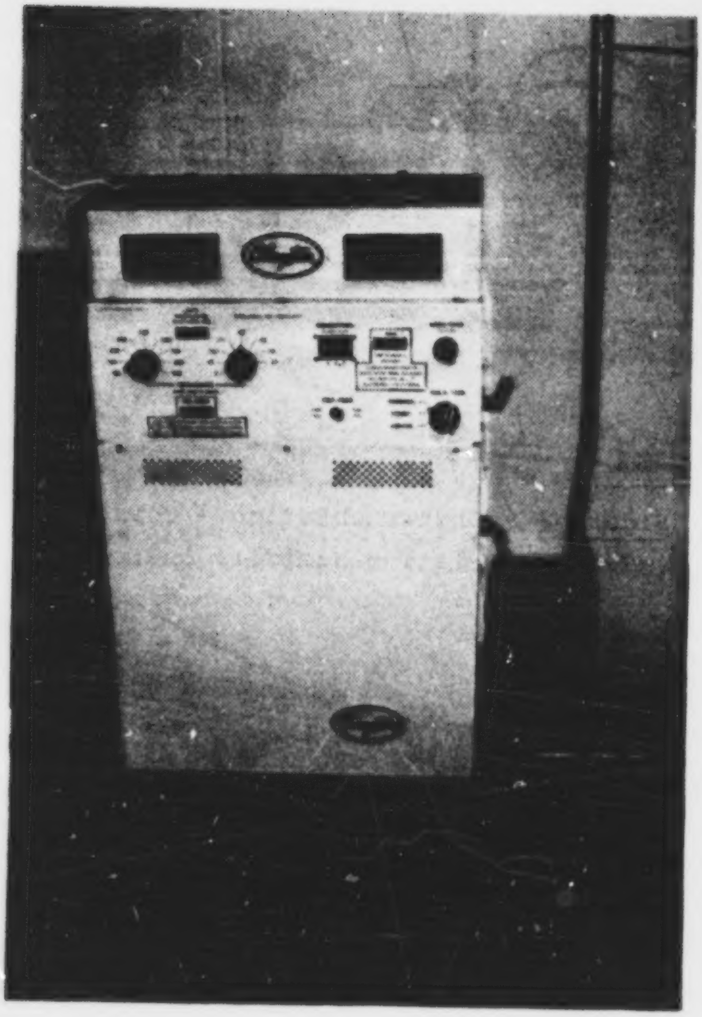


Figure 10 - Instrumentation - Dynamometer Road Load Power Control

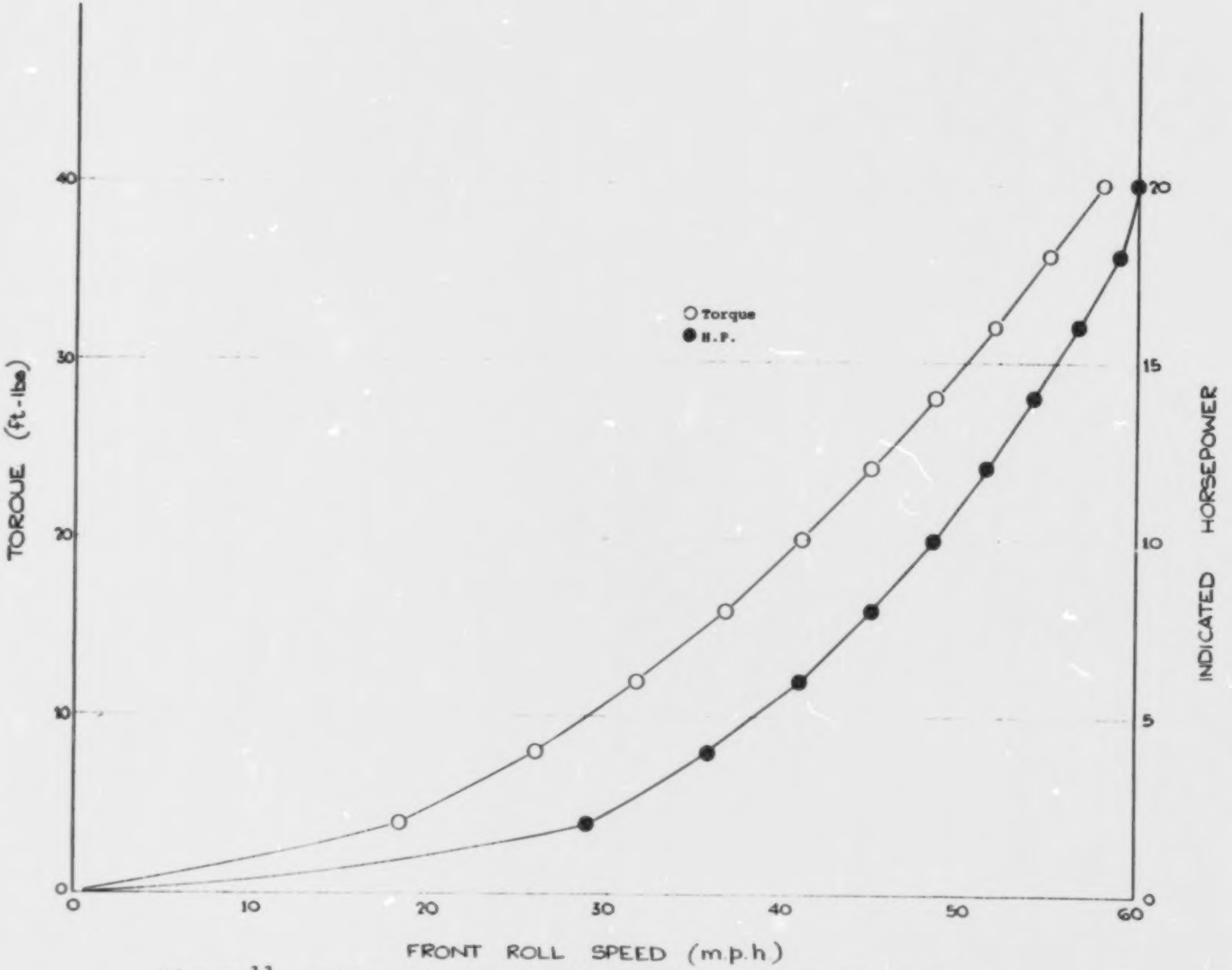


Figure 11 - Theoretical Torque/Horsepower Versus Front Roll Speed Characteristics For Clayton CTE 50 Dynamometer

Cars: #1 (109222)
#3 (117590)

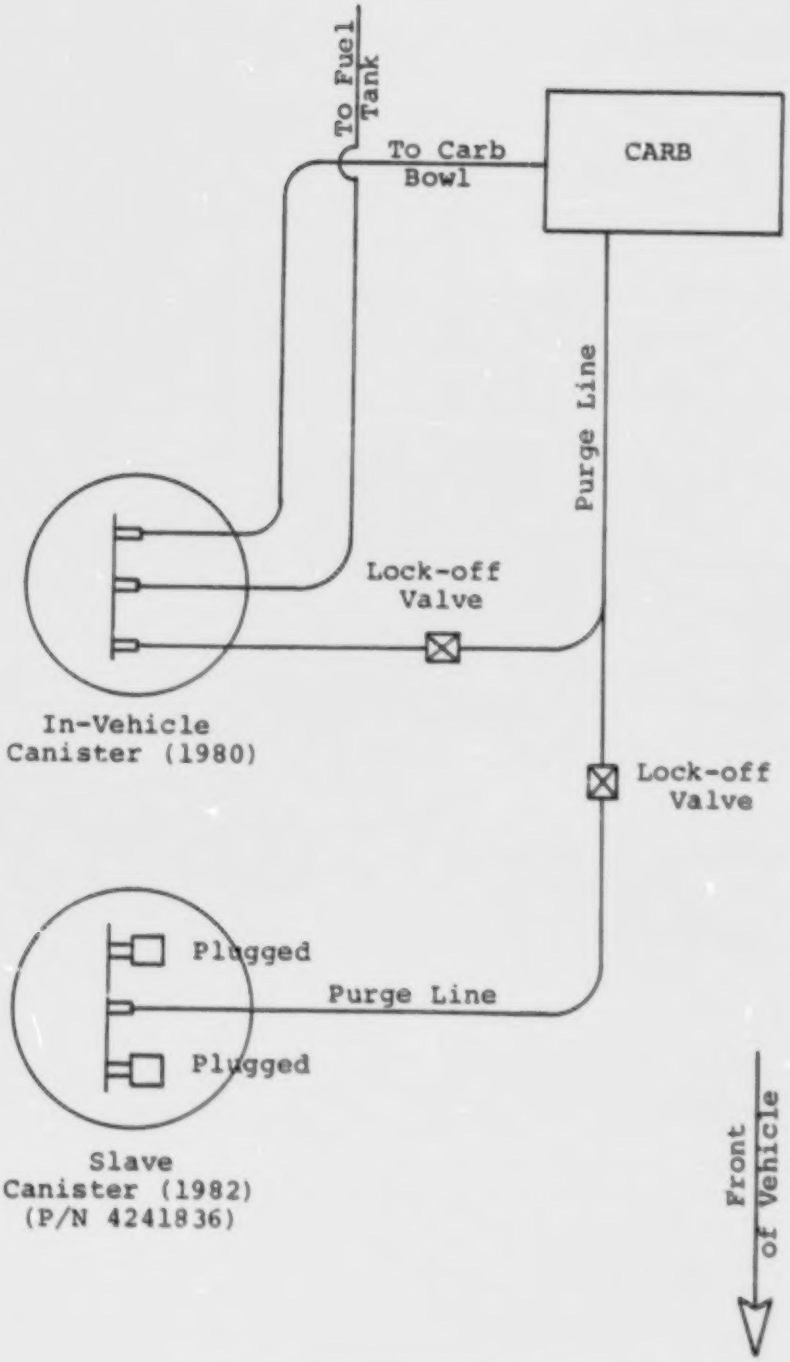

To Fuel Tank
To Carb Bowl
CARB
Purge Line
Lock-off Valve
In-Vehicle Canister (1980)
Lock-off Valve
Plugged
Purge Line
Plugged
Slave Canister (1982) (P/N 4241836)
Front of Vehicle

Figure 12 - Vapour Canister Hose Routing

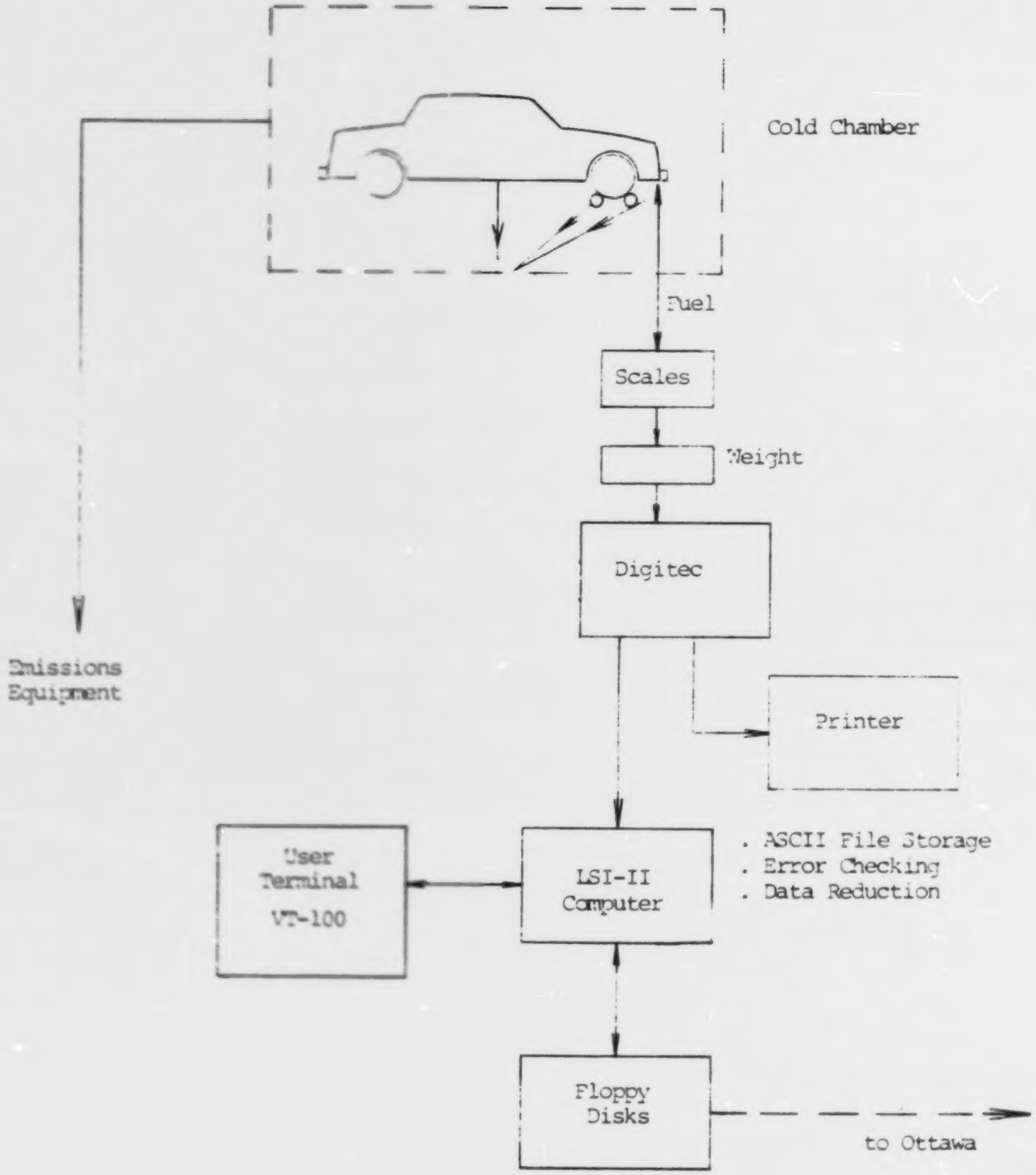
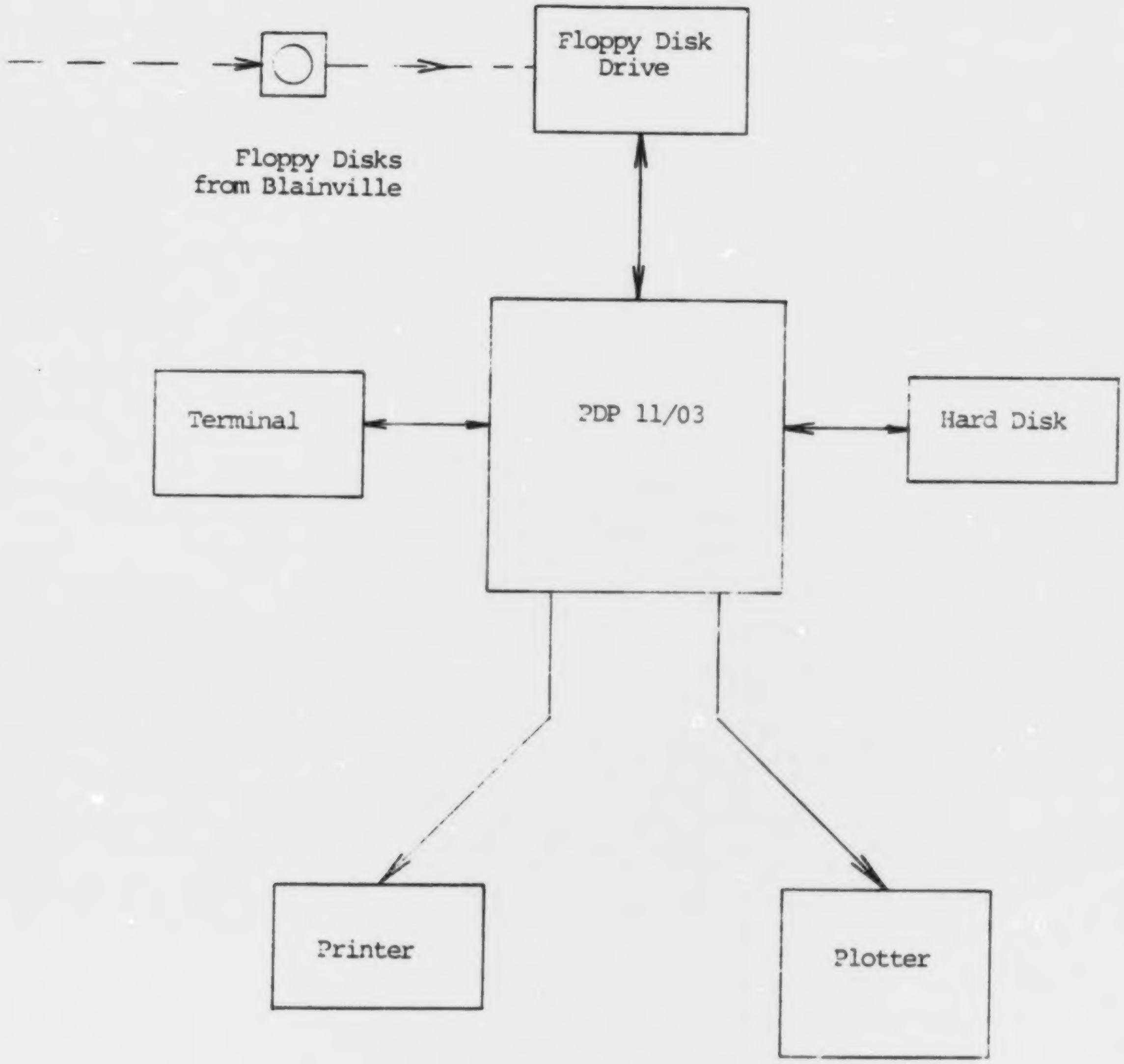

Cold Chamber
Fuel
Scales
Weight
Digitec
Printer
Emissions Equipment
User Terminal VT-100
LSI-II Computer
. ASCII File Storage
. Error Checking
. Data Reduction
Floppy Disks
to Ottawa

Figure 13 - Digital Data Collection


Floppy Disk Drive
Floppy Disks from Blainville
Terminal
PDP 11/03
Hard Disk
Printer
Plotter

- data reduction/printing/plotting
- mass storage/backup

Figure 14 - Digital Data Reduction

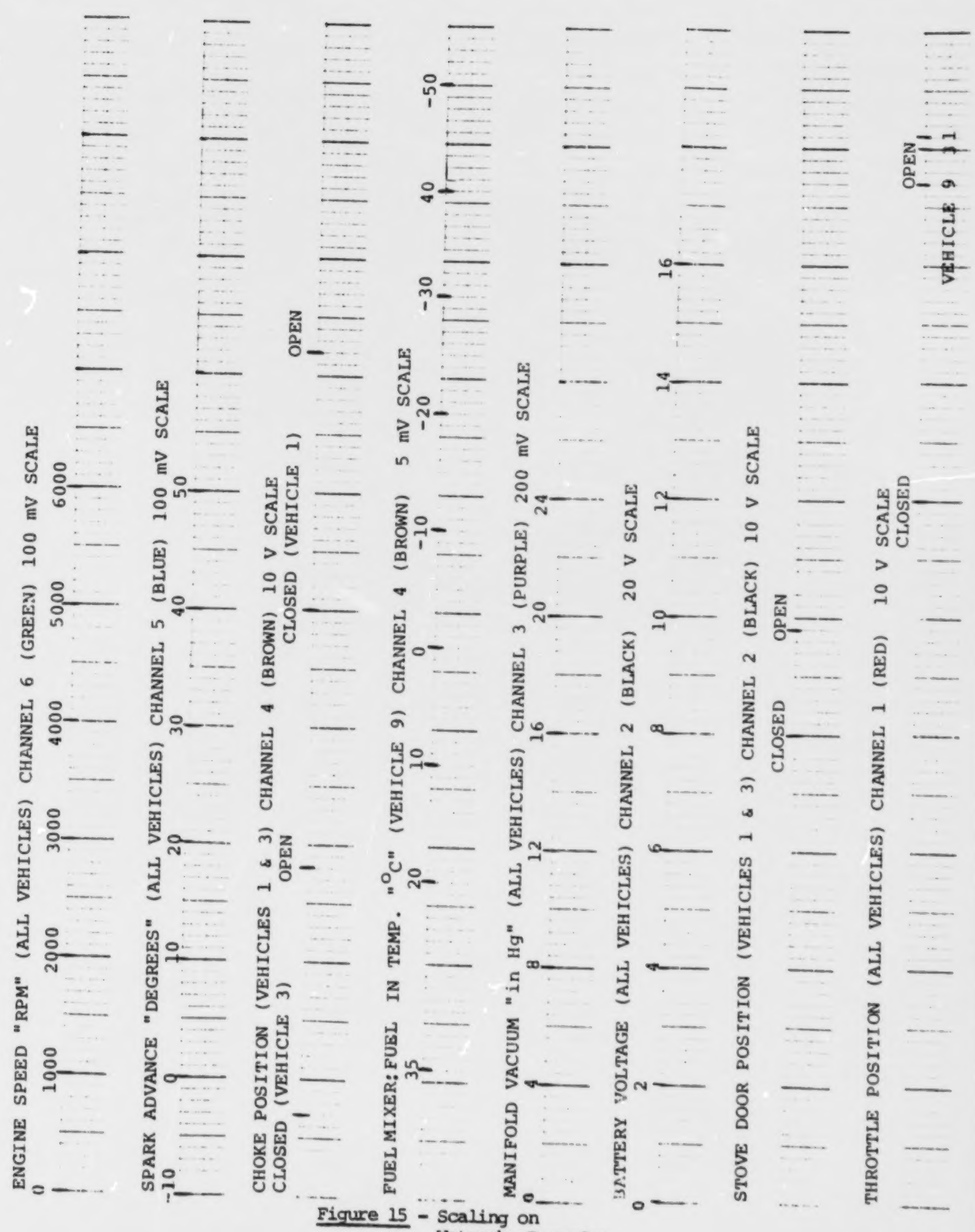

ENGINE SPEED "RPM" (ALL VEHICLES) CHANNEL 6 (GREEN) 100 mV SCALE
0
1000
2000
3000
4000
5000
6000
SPARK ADVANCE "DEGREES" (ALL VEHICLES) CHANNEL 5 (BLUE) 100 mV SCALE
-10
0
10
20
30
40
50
CHOKE POSITION (VEHICLES 1 & 3) CHANNEL 4 (BROWN) 10 V SCALE
CLOSED (VEHICLE 3)
OPEN
CLOSED (VEHICLE 1)
OPEN
FUEL MIXER; FUEL IN TEMP. "°C" (VEHICLE 9) CHANNEL 4 (BROWN) 5 mV SCALE
35
20
10
0
-10
-20
-30
40
-50
MANIFOLD VACUUM "in Hg" (ALL VEHICLES) CHANNEL 3 (PURPLE) 200 mV SCALE
0
4
8
12
16
20
24
BATTERY VOLTAGE (ALL VEHICLES) CHANNEL 2 (BLACK) 20 V SCALE
0
2
4
6
8
10
12
14
16
STOVE DOOR POSITION (VEHICLES 1 & 3) CHANNEL 2 (BLACK) 10 V SCALE
CLOSED
OPEN
THROTTLE POSITION (ALL VEHICLES) CHANNEL 1 (RED) 10 V SCALE
CLOSED
OPEN
VEHICLE 9
11

Figure 15 - Scaling on Watanabe Recorder

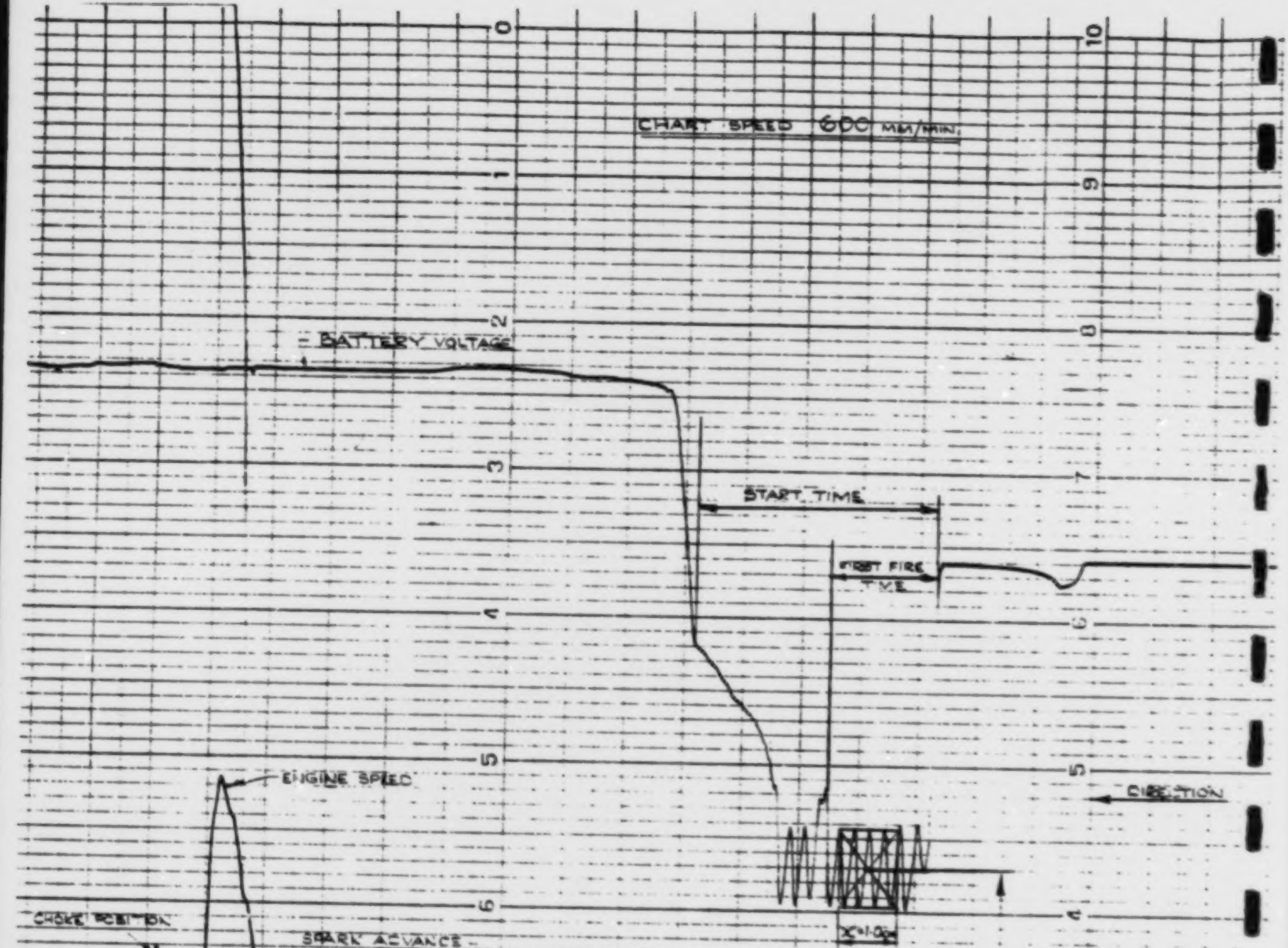


Fig. 16 - Startup Portion of Analog Recorder Output

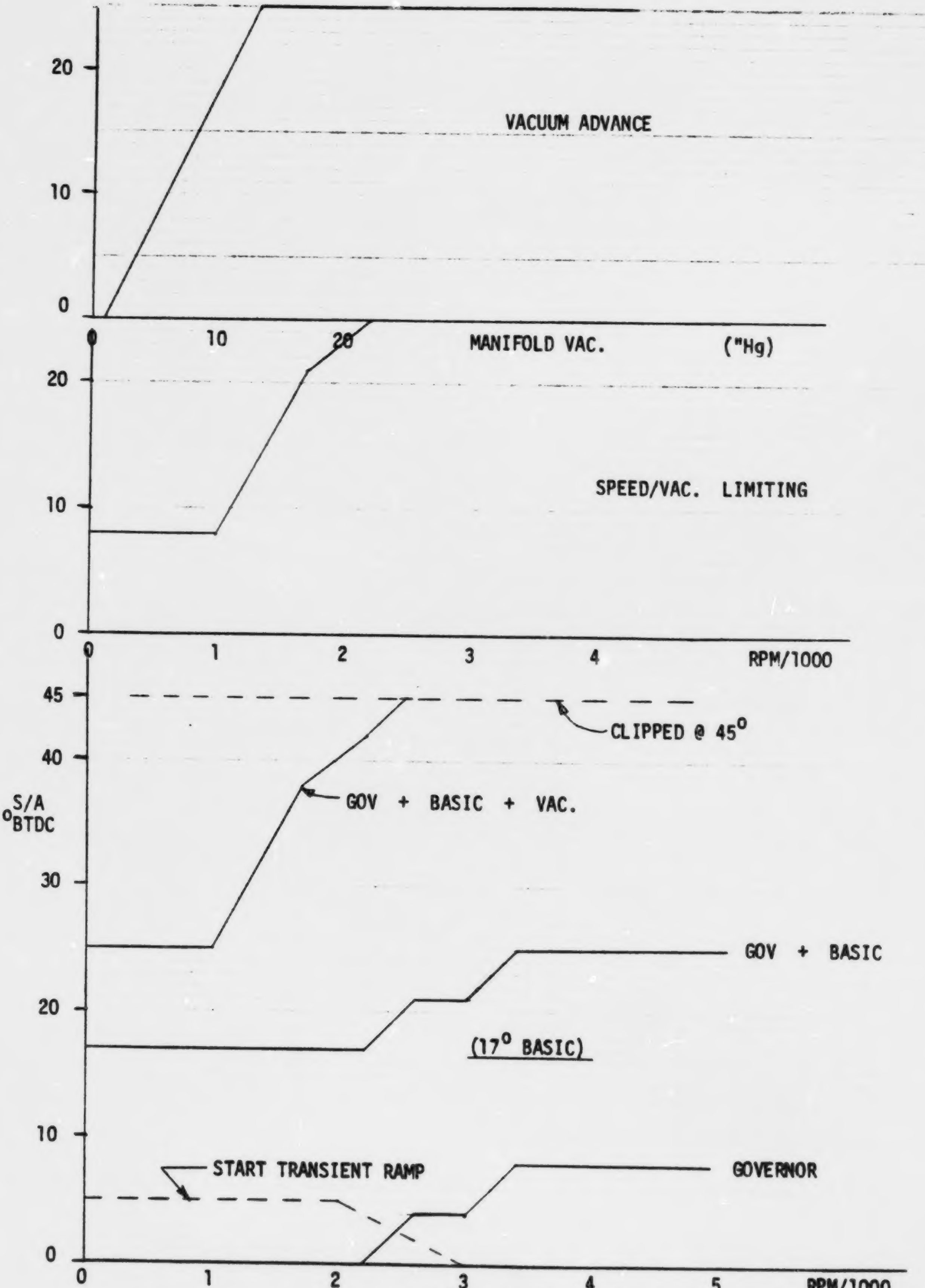


Figure 17 - Vehicle No. 1 - Base Configuration Spark Curve

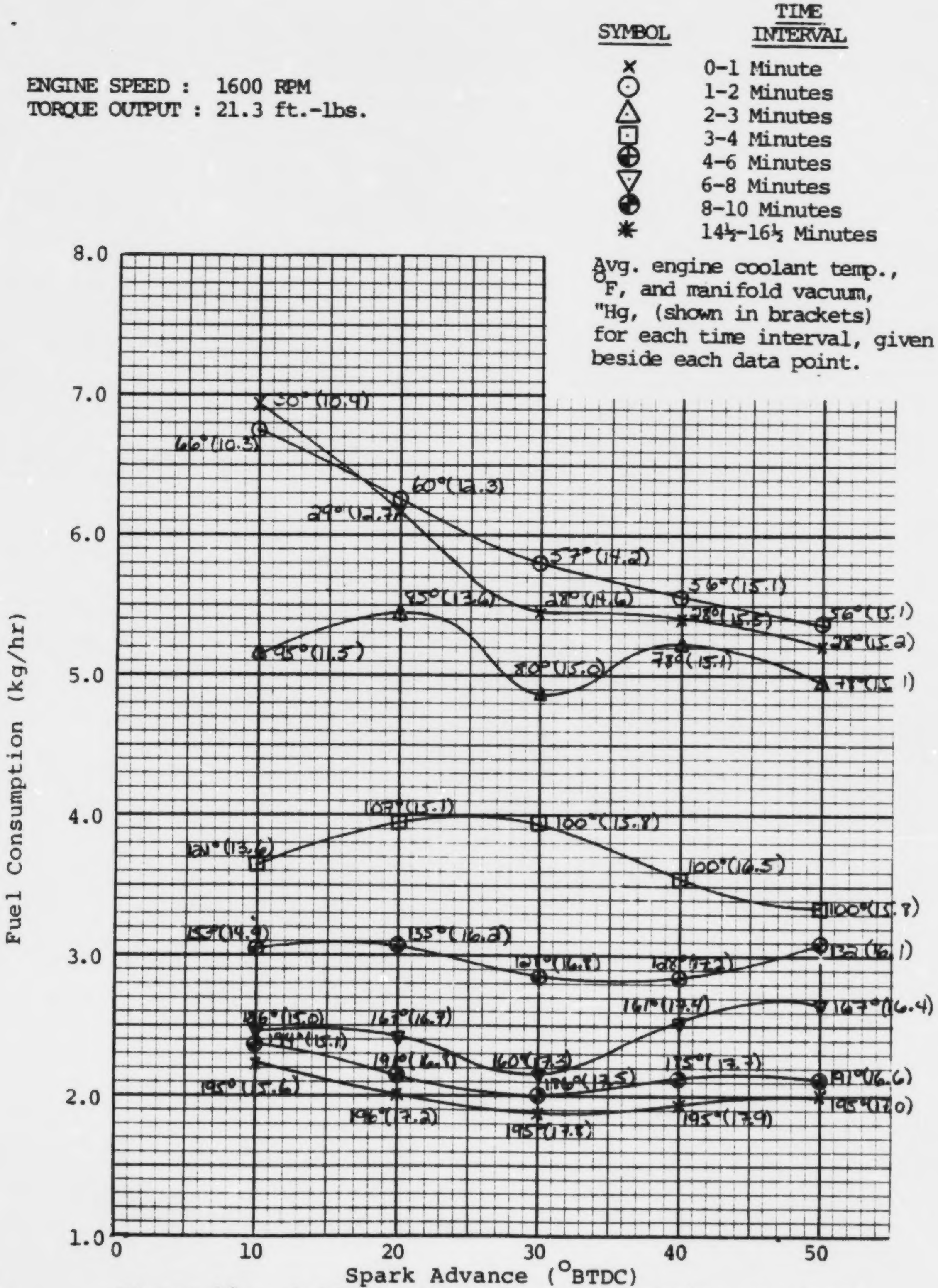


Figure 18 - Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval

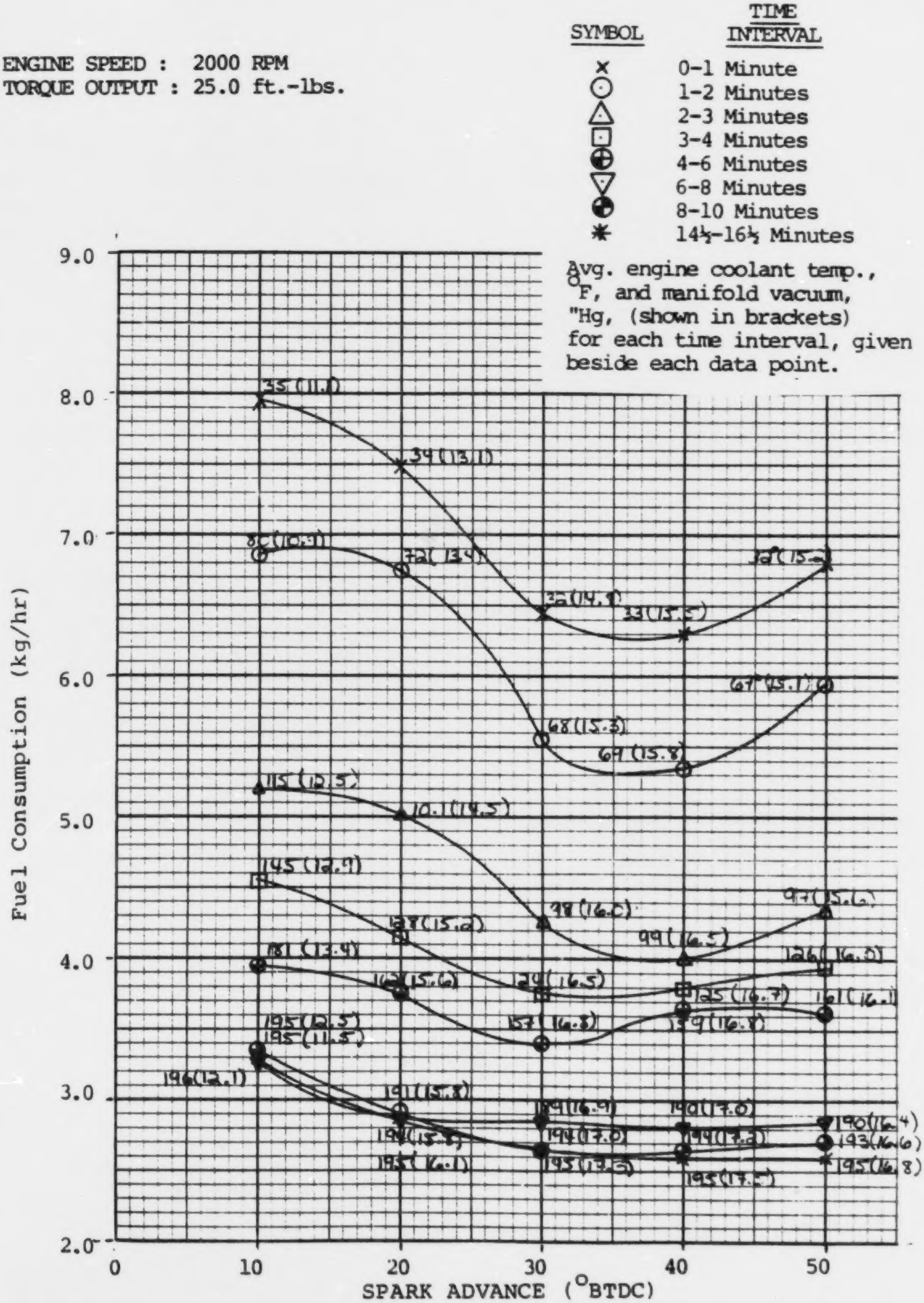


Figure 19 - Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval

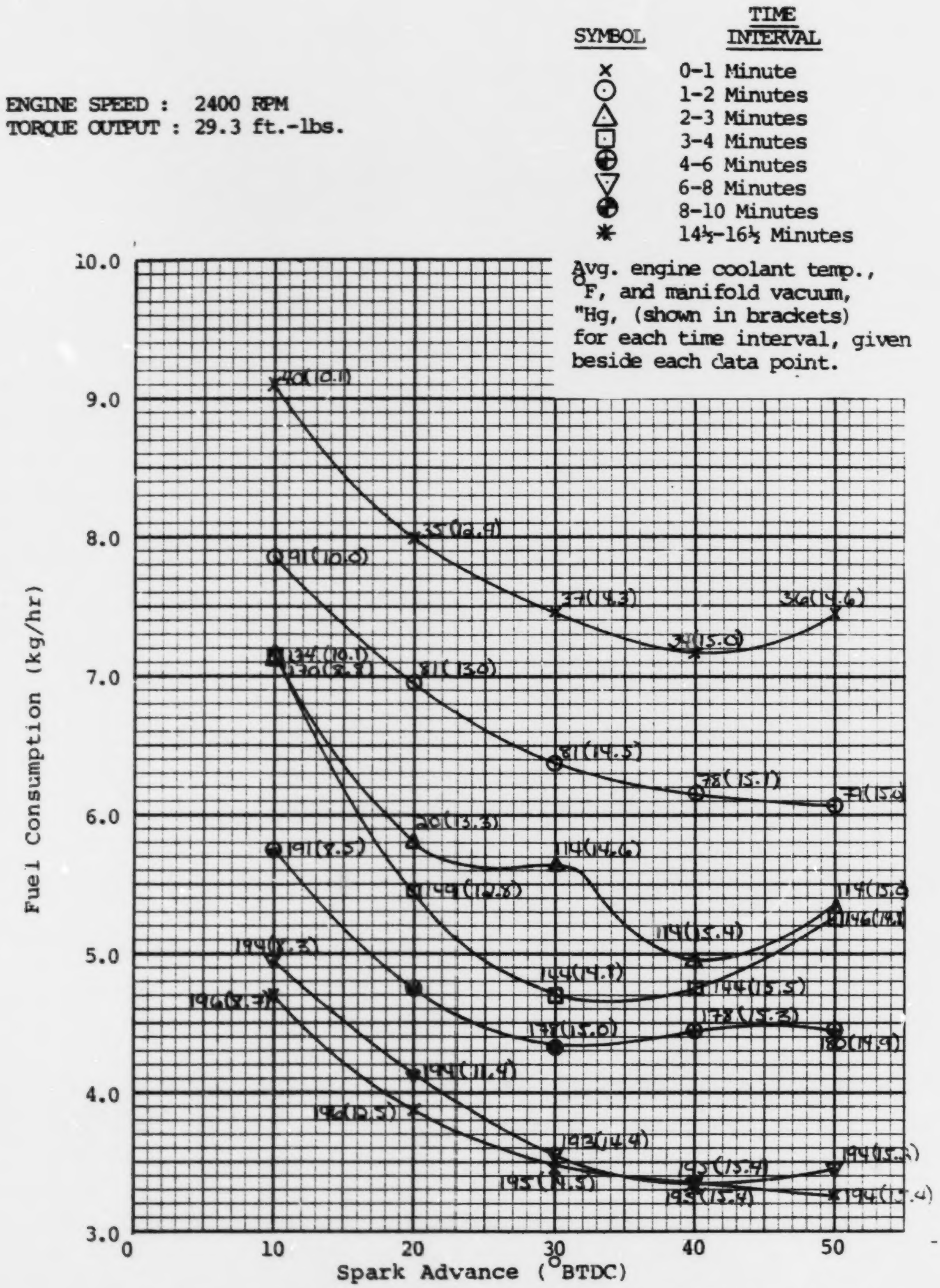
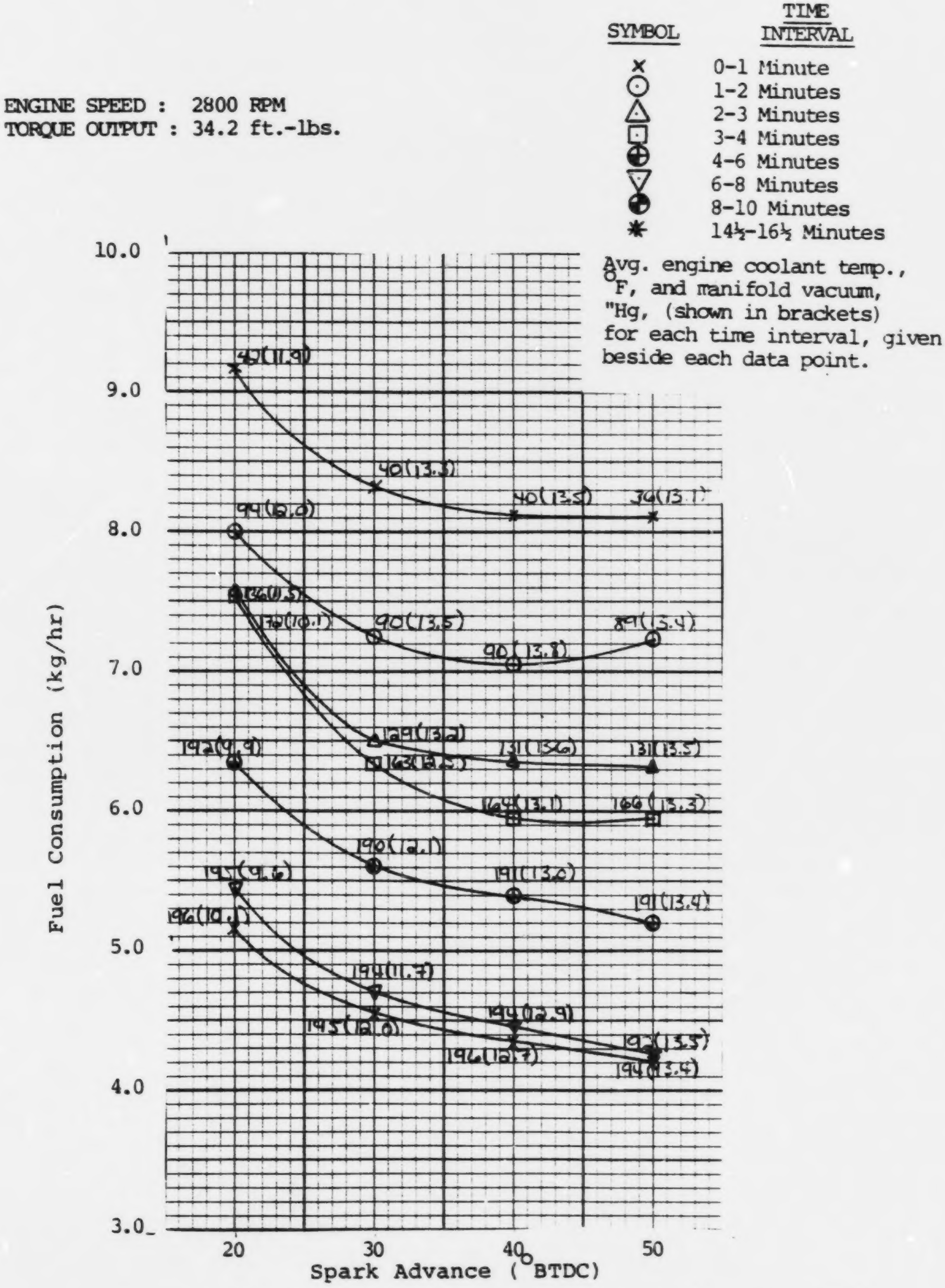


Figure 20 - Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval



ENGINE SPEED : 2800 RPM
TORQUE OUTPUT : 34.2 ft.-lbs.

Avg. engine coolant temp., °F, and manifold vacuum, "Hg, (shown in brackets) for each time interval, given beside each data point.

Figure 21 - Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval

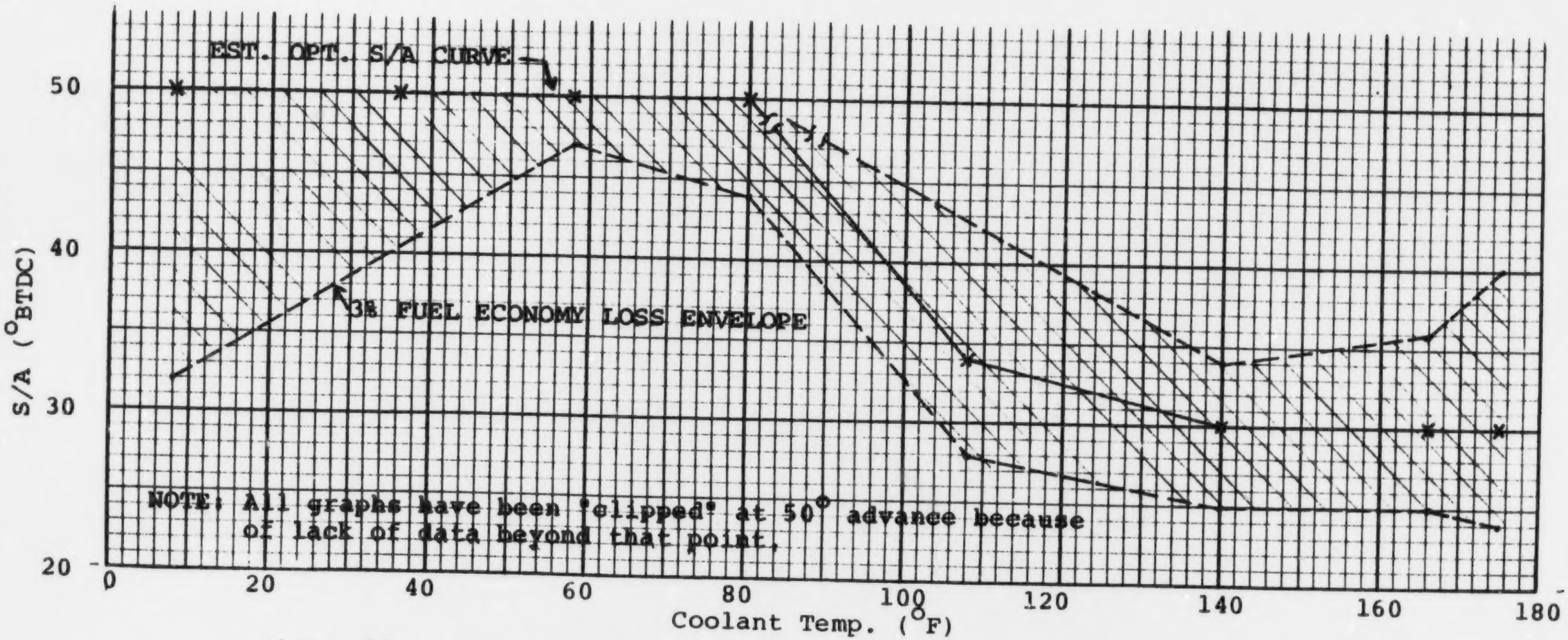
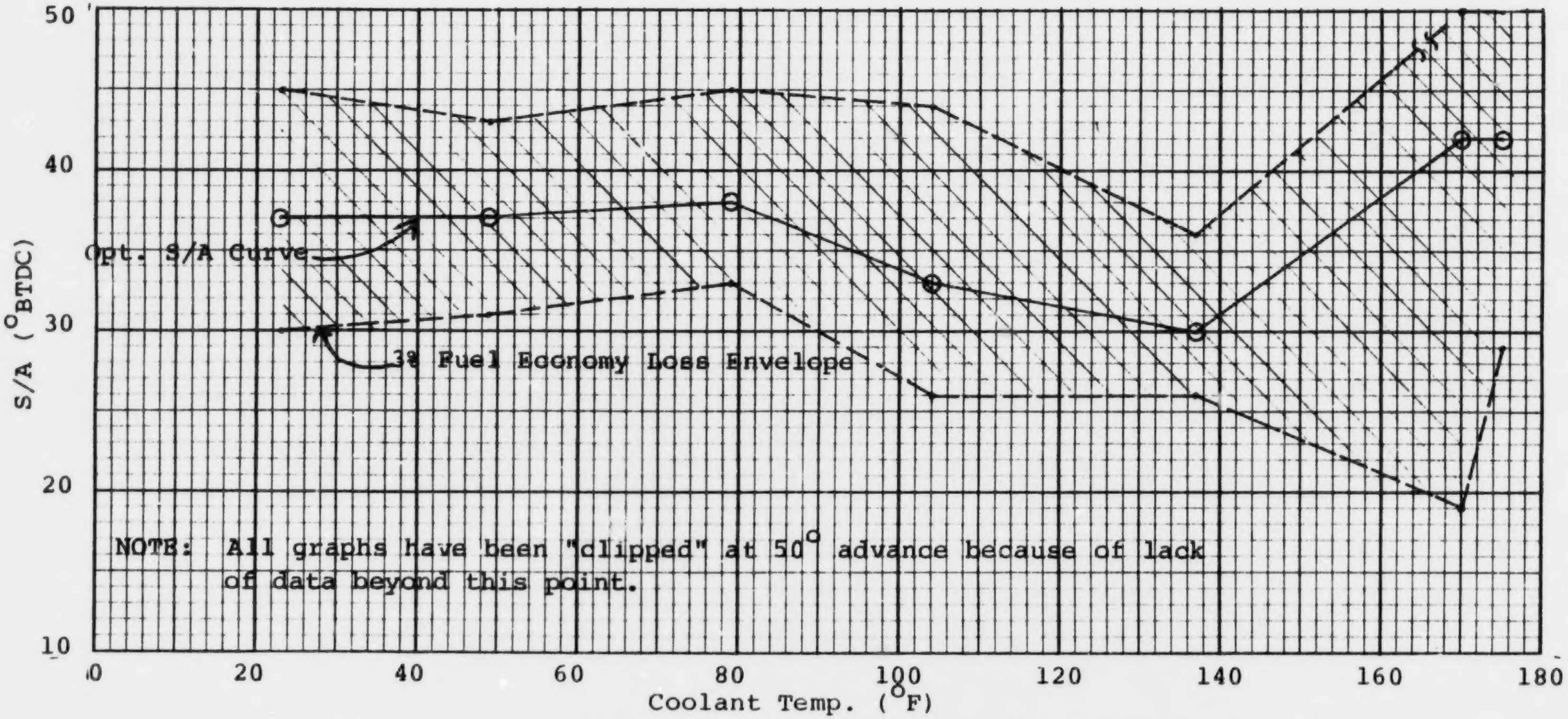


Figure 22 - Optimum Road Load S/A vs. Engine Coolant Temp. @ 1600 RPM
- Spark Optimized For Fuel Consumption Only
- Data Based On Graphs of "Cold Transients Fuel Consumption vs. Spark Advance For Constant Time Interval".



NOTE: All graphs have been "clipped" at 50° advance because of lack of data beyond this point.

Figure 23 - Optimum Road Load S/A vs. Engine Coolant Temp. @ 2000 RPM
- Spark Optimized For Fuel Consumption Only
- Data Based On Graphs Of "Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval"

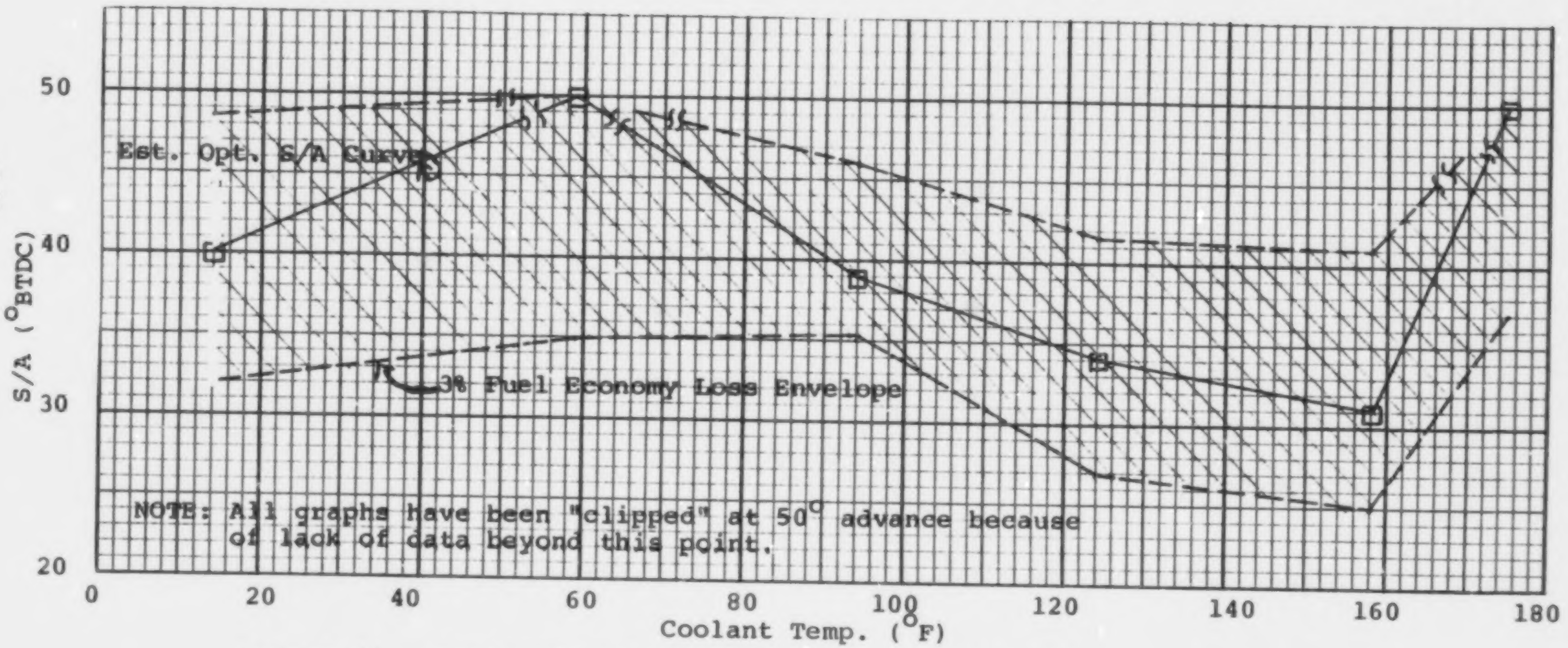
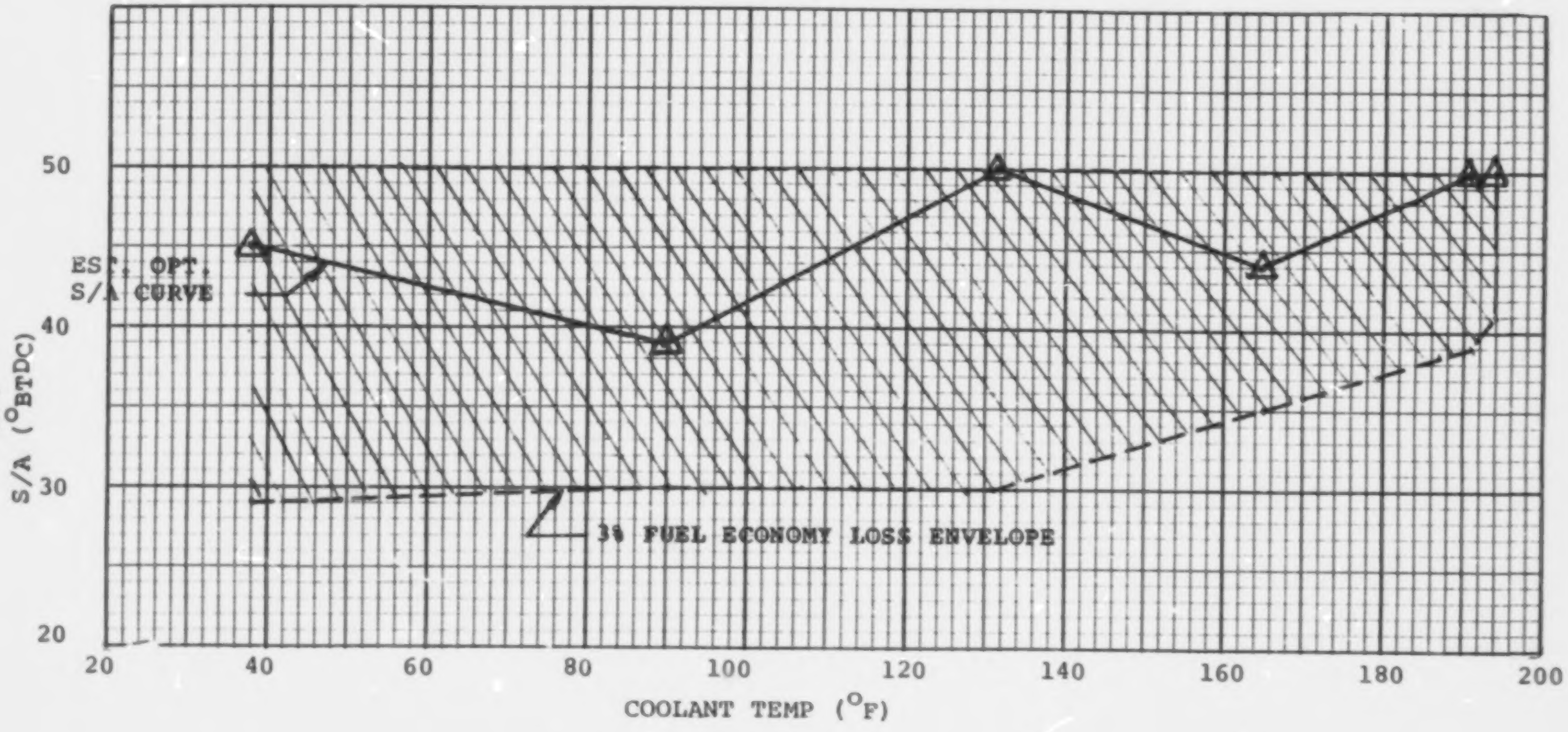


Figure 24 - Optimum Road Load S/A vs. Engine Coolant Temp. @ 2400 RPM
- Spark Optimized For Fuel Consumption Only
- Data Based On Graphs of "Cold Transient Fuel Consumption vs. Spark Advance For Constant Time Interval".

FIGURE 25

OPTIMUM ROAD LOAD S/A VS ENGINE COOLANT TEMP @ 2800 RPM

- Spark optimized for fuel consumption only
- Data based on graphs of "Cold Transient Fuel Consumption vs Spark Advance for Constant Time Interval"



NOTE: All graphs have been "clipped" at 50° advance because of lack of data beyond that point.

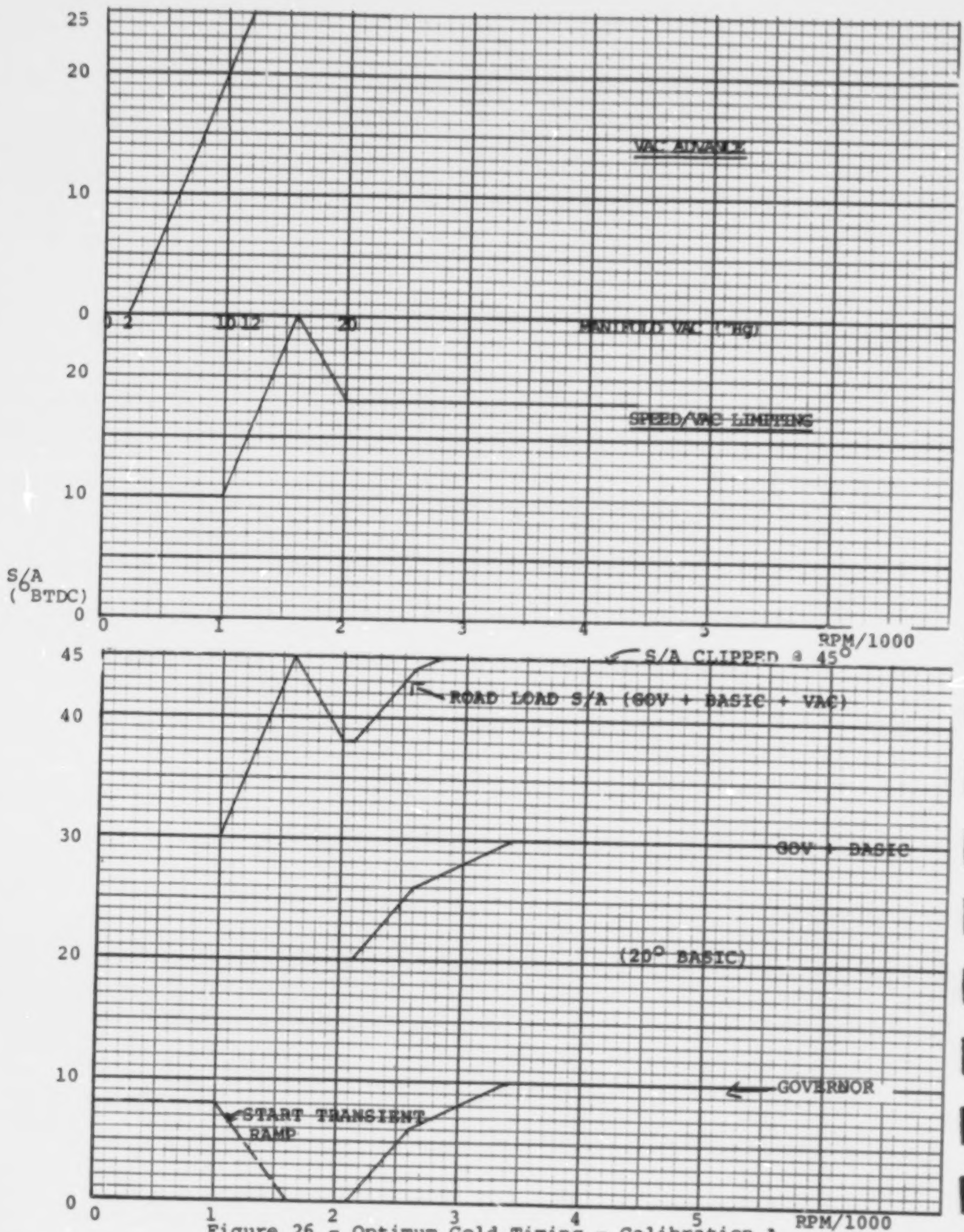


Figure 26 - Optimum Cold Timing - Calibration A

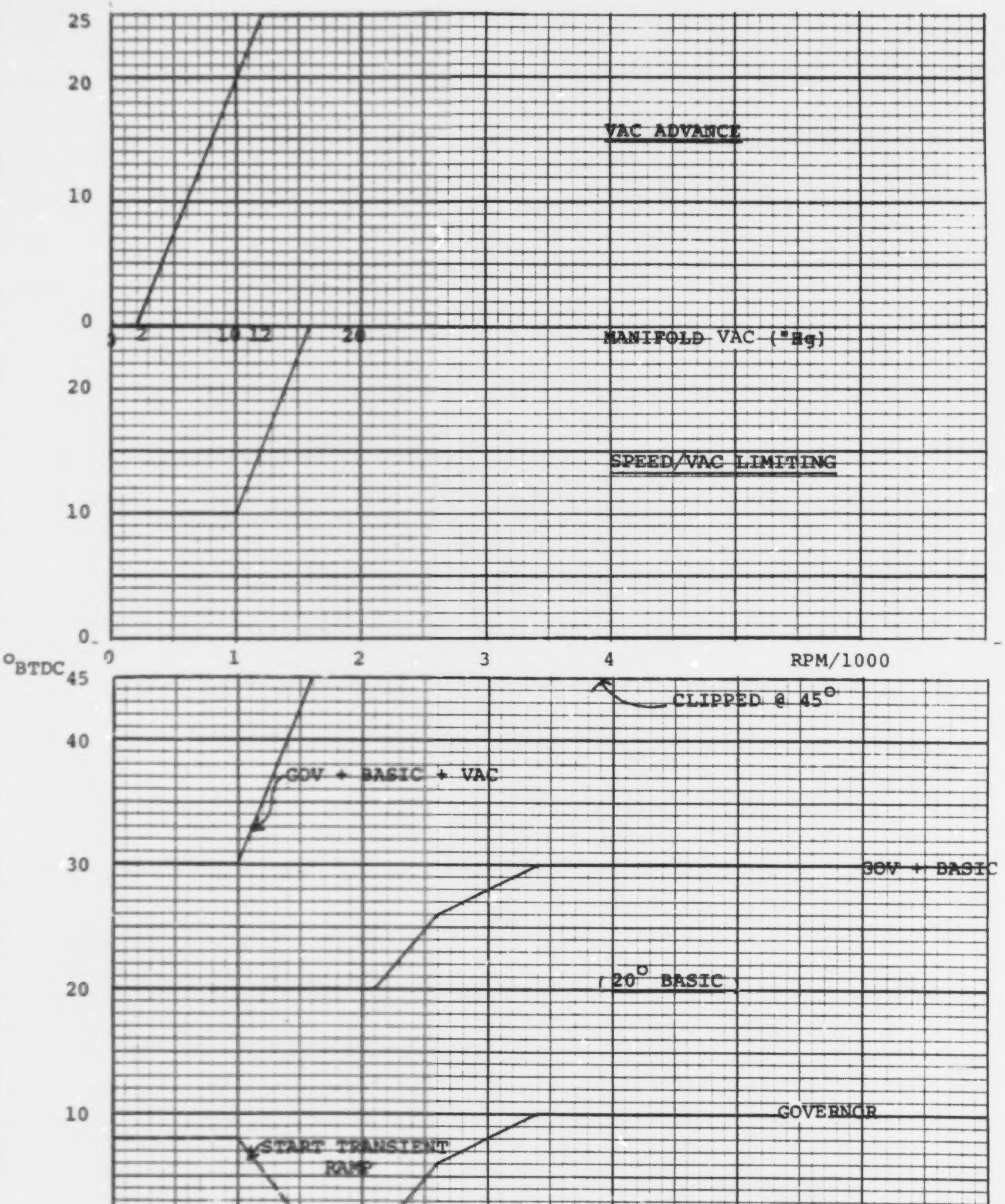


Figure 27 - Optimum Cold Timing - Calibration B

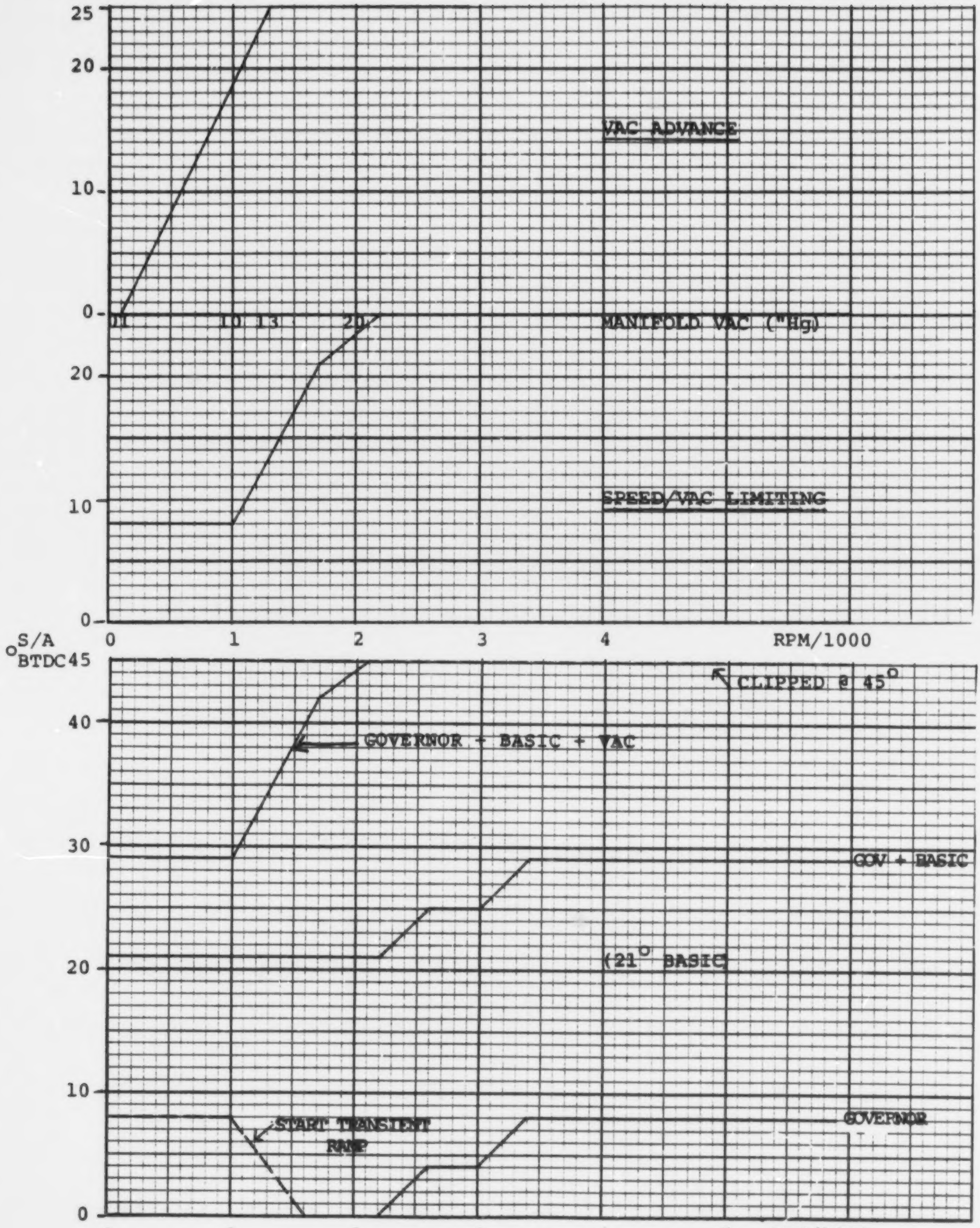


Figure 28 - Optimum Cold Timing - Calibration C

FIGURE 29 VEHICLE #3 - AUTOMATIC IDLE SPEED SPARK CURVE "BASE" PROM

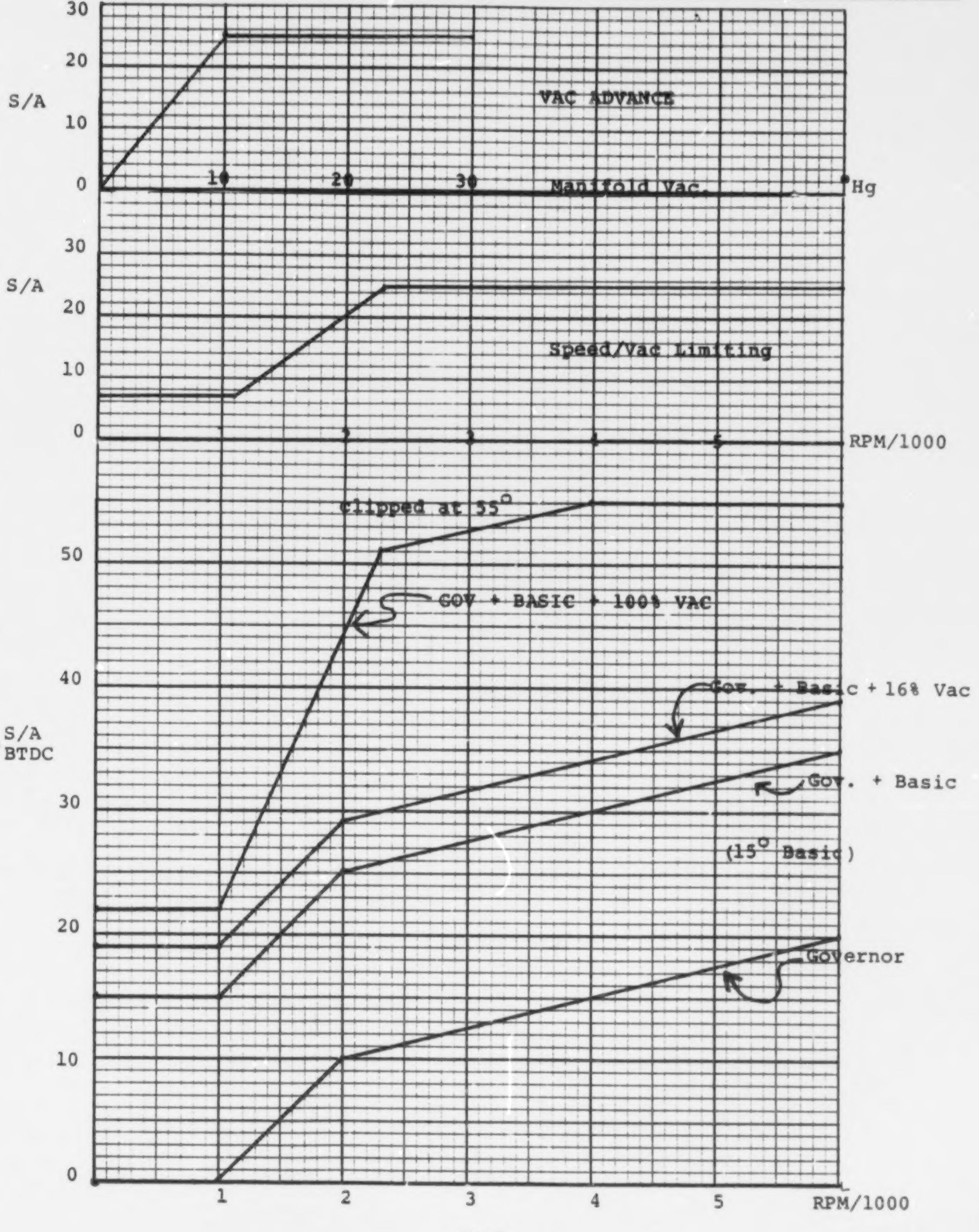


FIGURE 30 VEHICLE #3 - AUTOMATIC IDLE SPEED PROM "A"

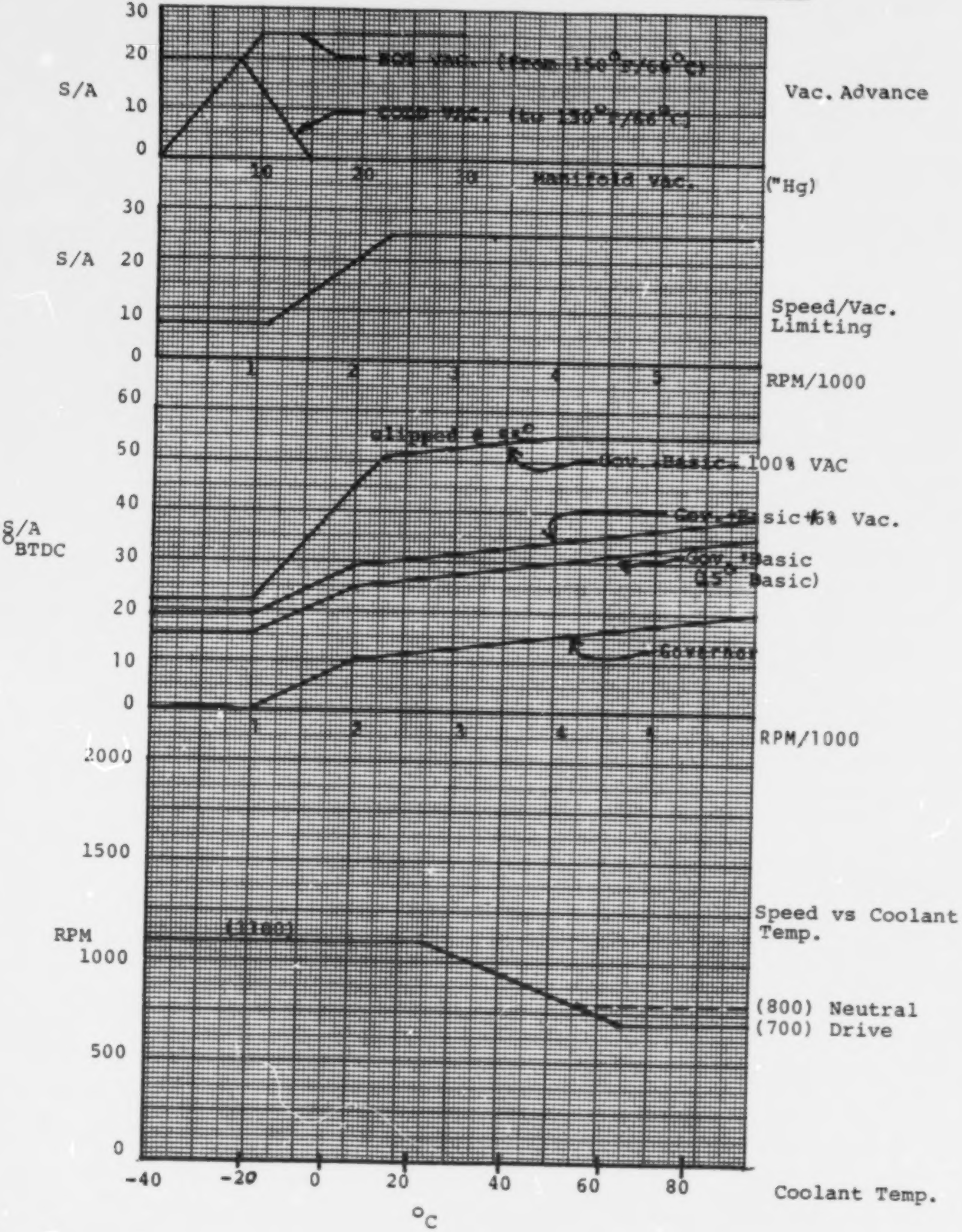


FIGURE 31 VEHICLE #3 - AUTOMATIC IDLE SPEED PROM "A-1" AND A-1'

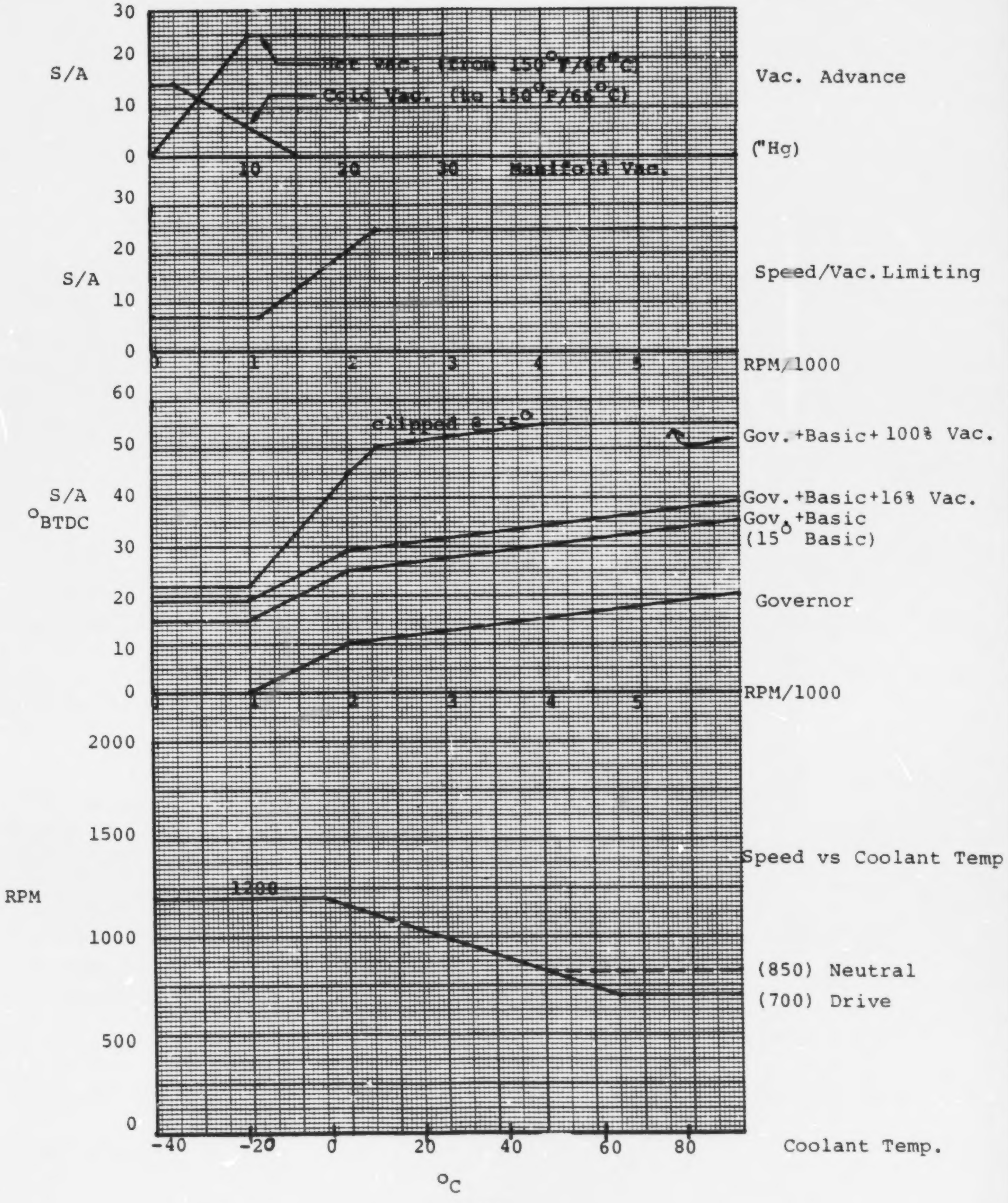
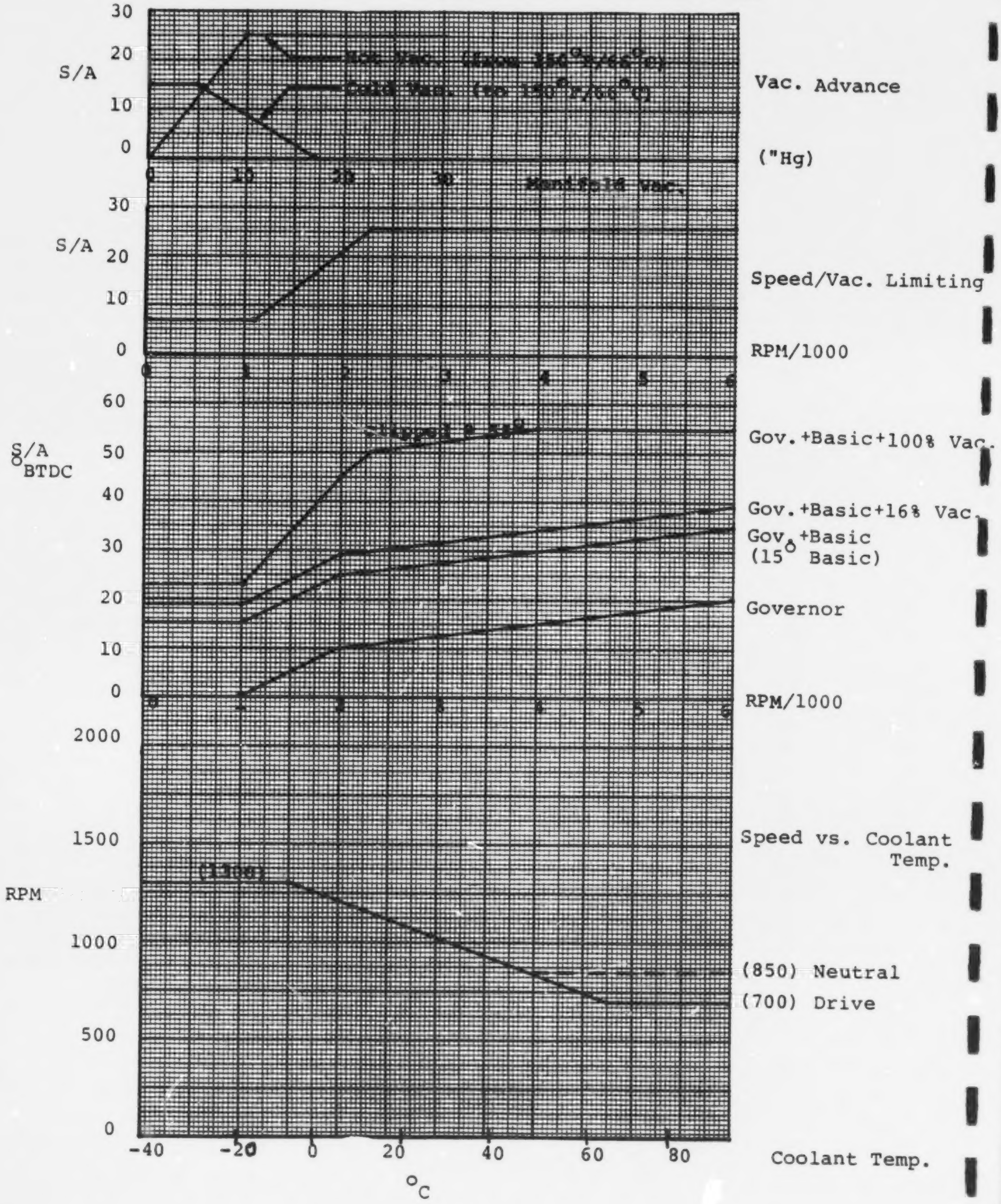


FIGURE 32 VEHICLE #3 - AUTOMATIC IDLE SPEED PROM 'A-2'



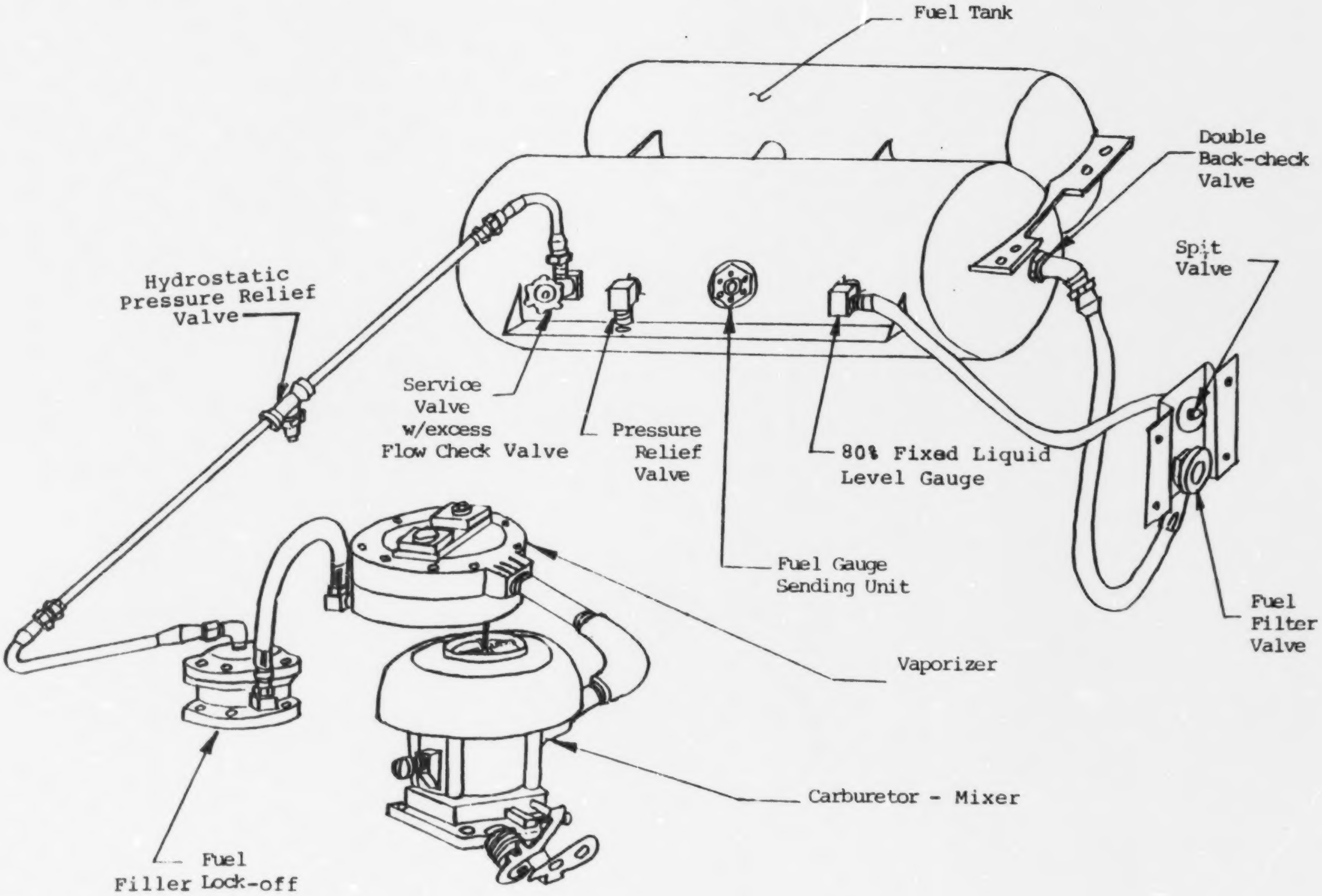

Fuel Tank
Double Back-check Valve
Spit Valve
Hydrostatic Pressure Relief Valve
Service Valve w/excess Flow Check Valve
Pressure Relief Valve
80% Fixed Liquid Level Gauge
Fuel Gauge Sending Unit
Fuel Filter Valve
Vaporizer
Carburetor - Mixer
Fuel Filler Lock-off

Figure 33 - Propane Fuel System

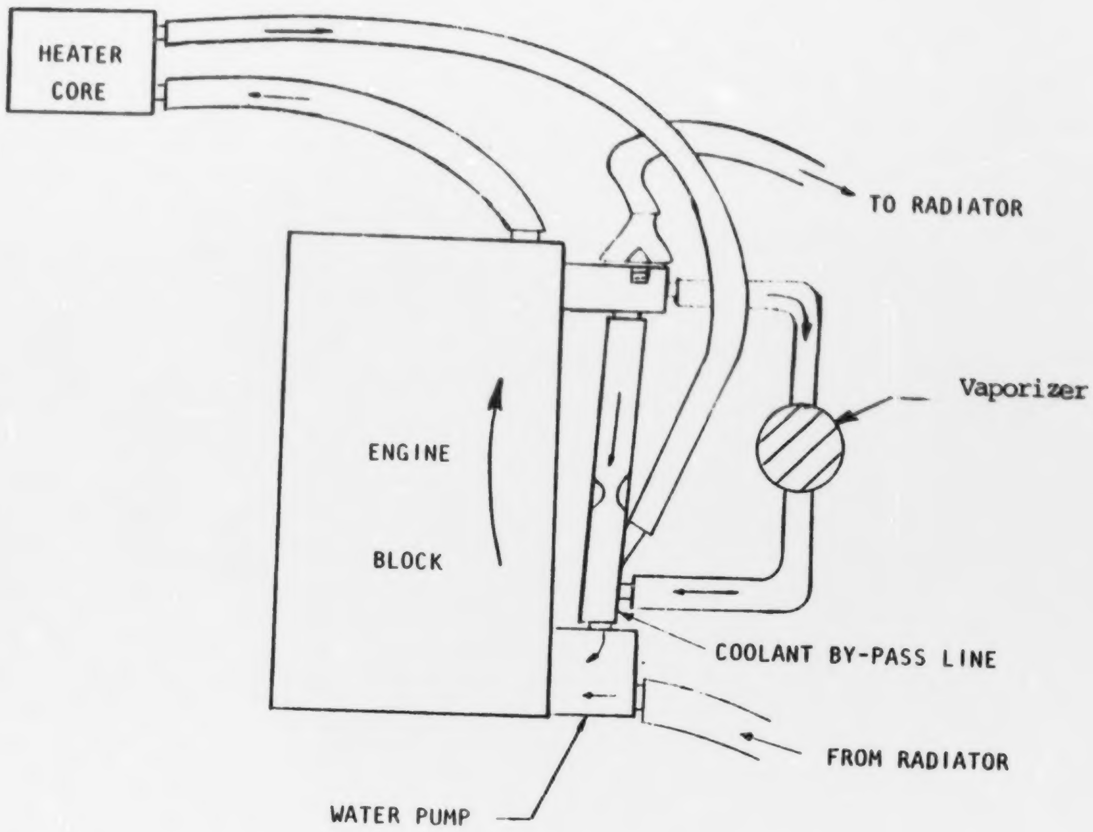

HEATER CORE
TO RADIATOR
Vaporizer
ENGINE
BLOCK
COOLANT BY-PASS LINE
FROM RADIATOR
WATER PUMP

Figure 34 - Propane Vehicle - Calibration A Schematic

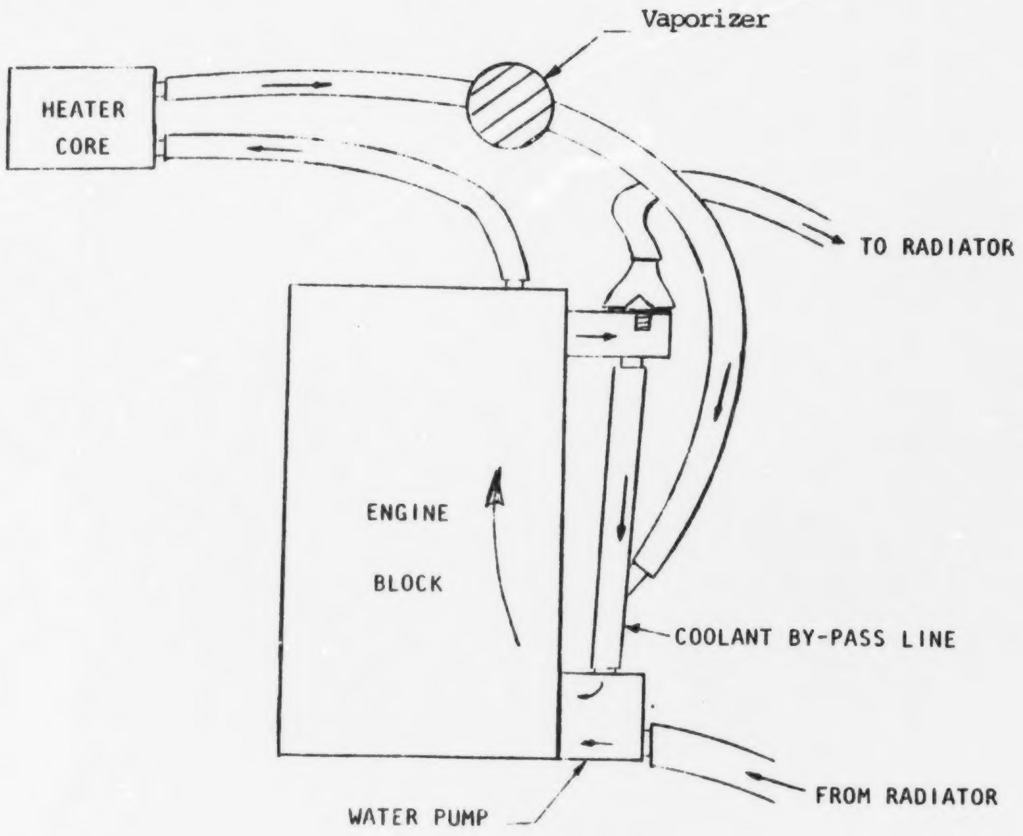

Vaporizer
HEATER CORE
TO RADIATOR
ENGINE BLOCK
COOLANT BY-PASS LINE
FROM RADIATOR
WATER PUMP

Figure 35 - Propane Vehicle - Calibration B Schematic

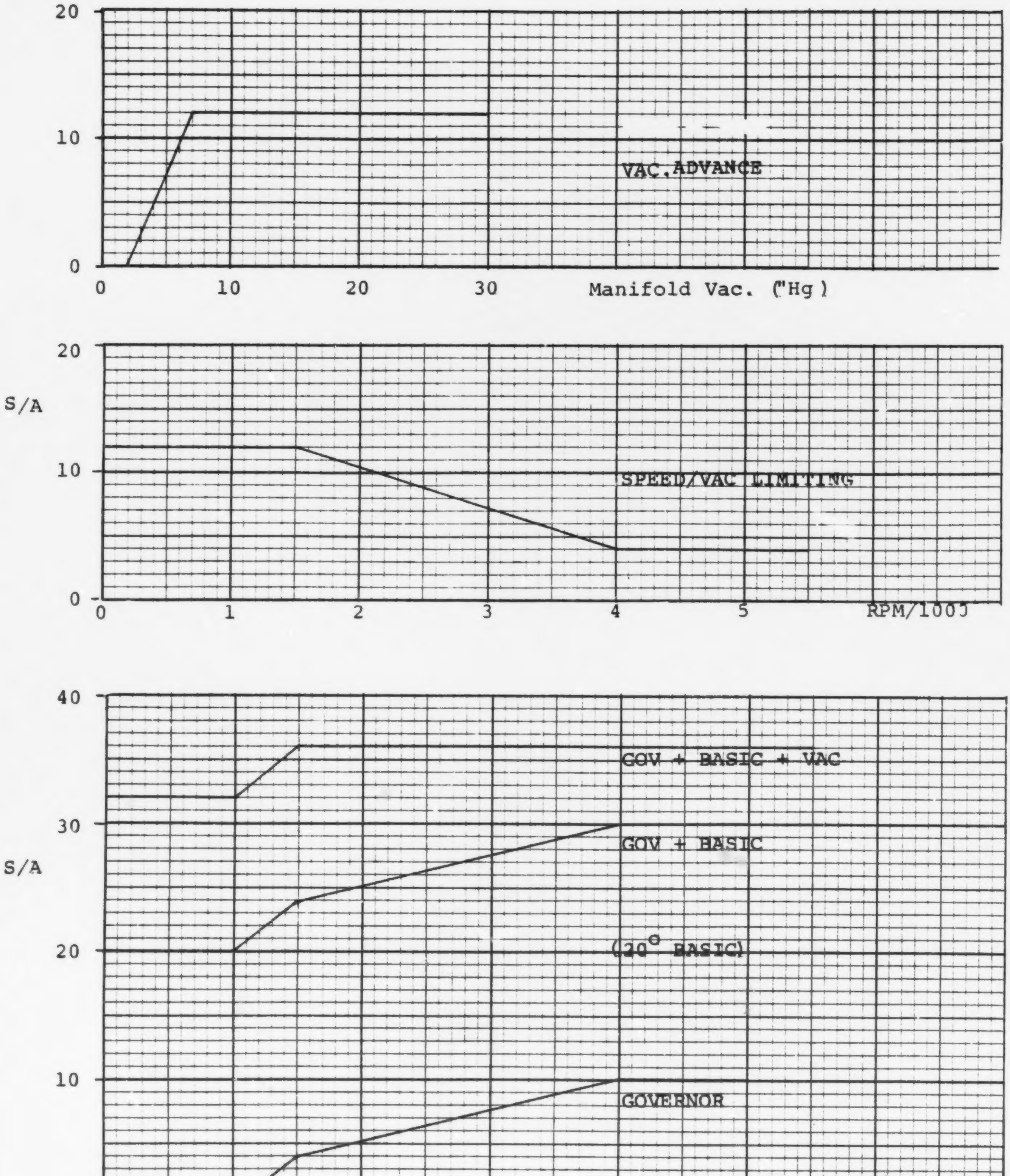


Figure 36 - Vehicle No. 9 - Propane - PROM AP1

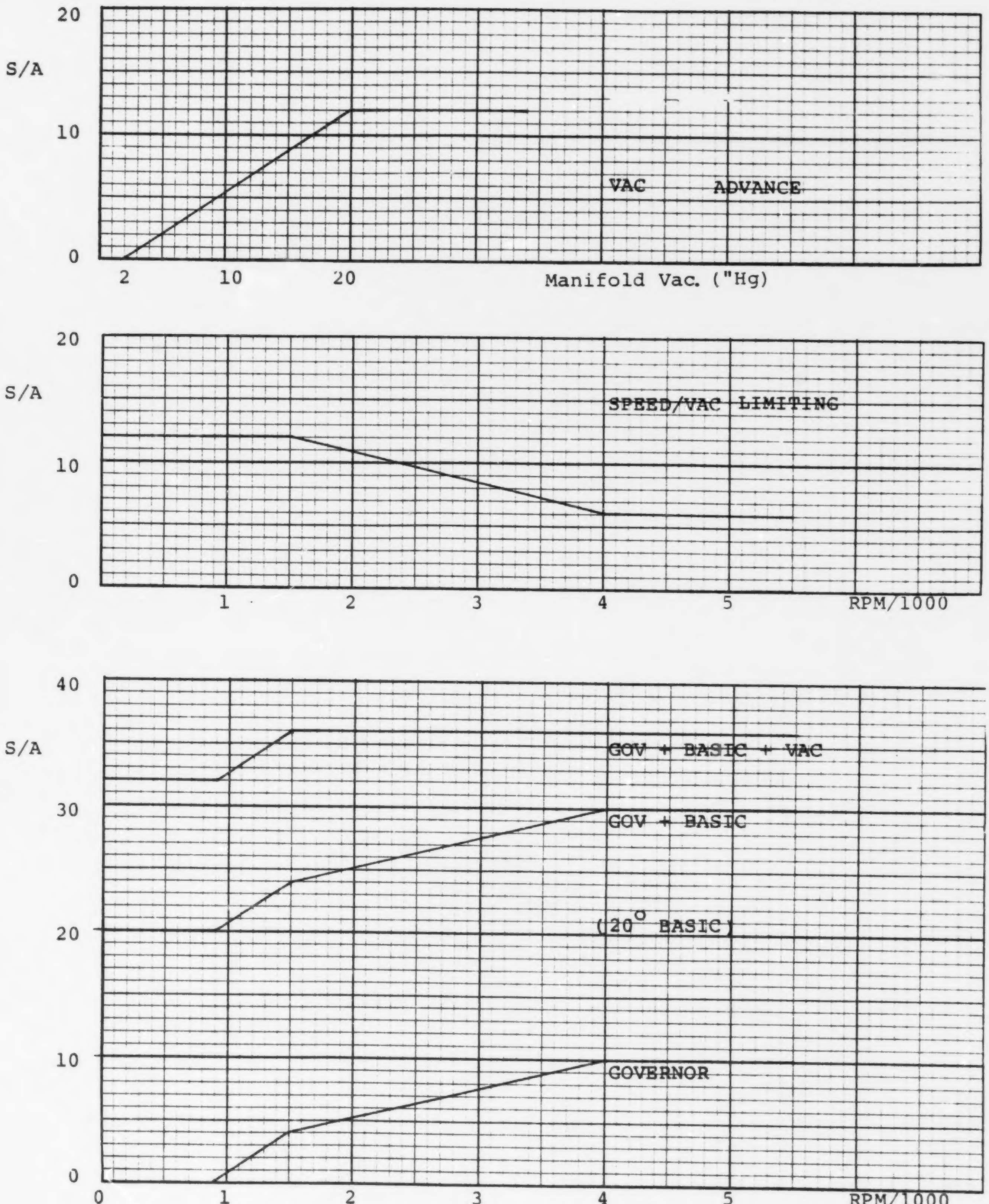


Figure 37 - Vehicle No. 9 - Propane - PROM 2PB

Figure 38

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.2-3 TEST TEMPERATURE: 25 C

CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

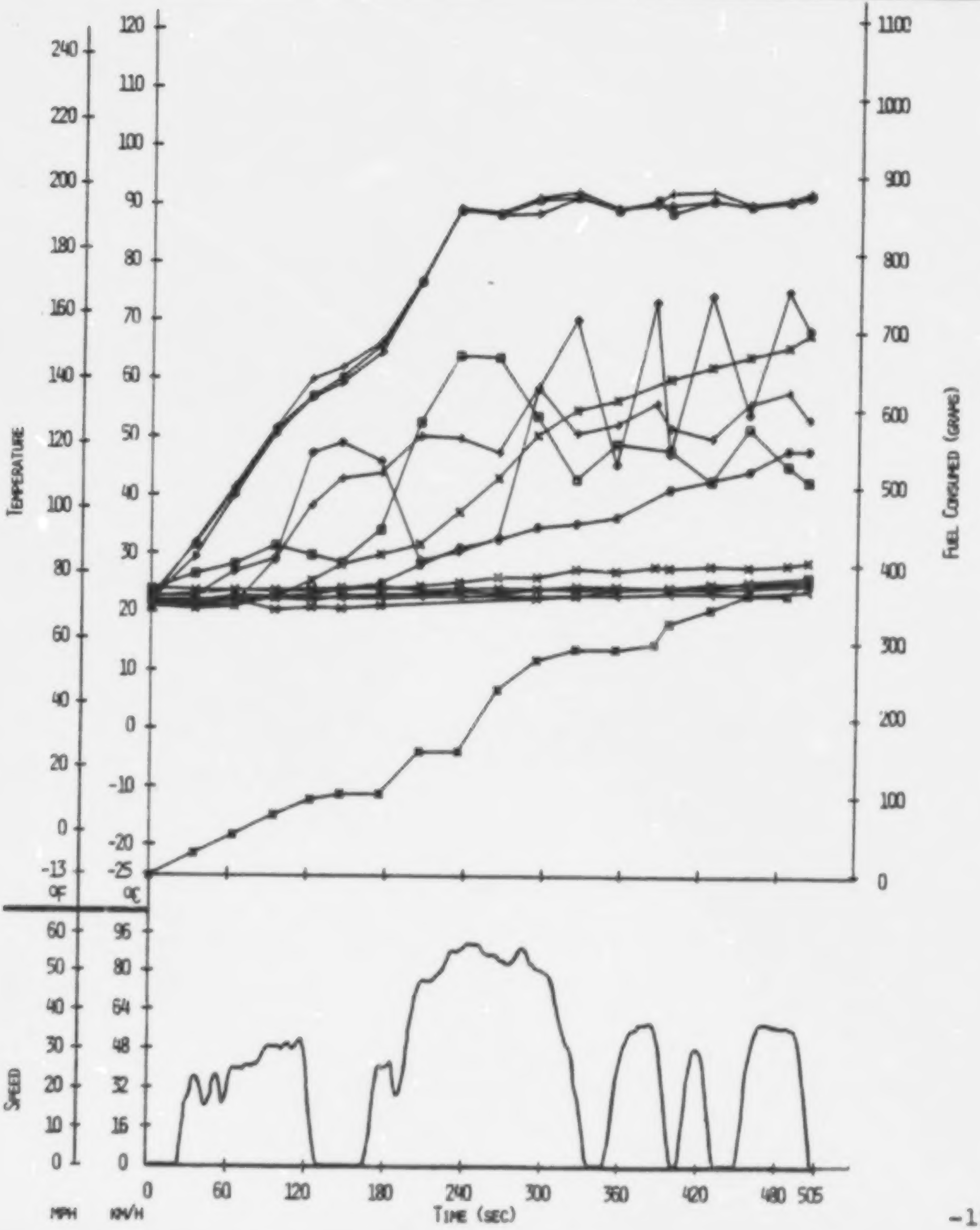
HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)

- + — Coolant - Thermostat
- → — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⊟ — Stove Output
- ⌘ — Eng. Oil @ Dipstick
- ✥ — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ꟿ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel In - Carb. Bowl
- ✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 39**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.2-3 TEST TEMPERATURE: 25 C

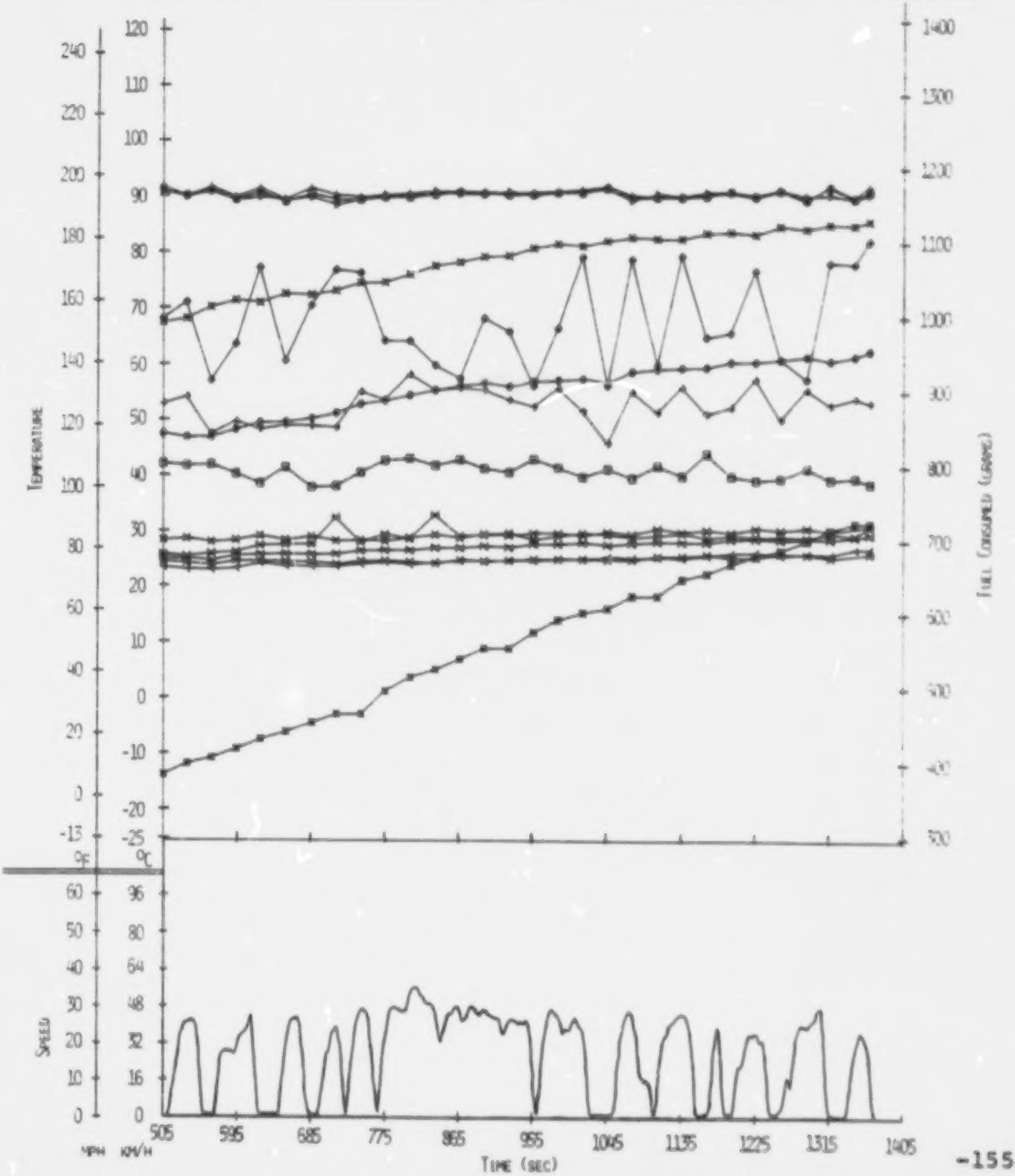
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◑ — Int. Manifold Runner
⊡ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 40

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.2-3 TEST TEMPERATURE: 25 C

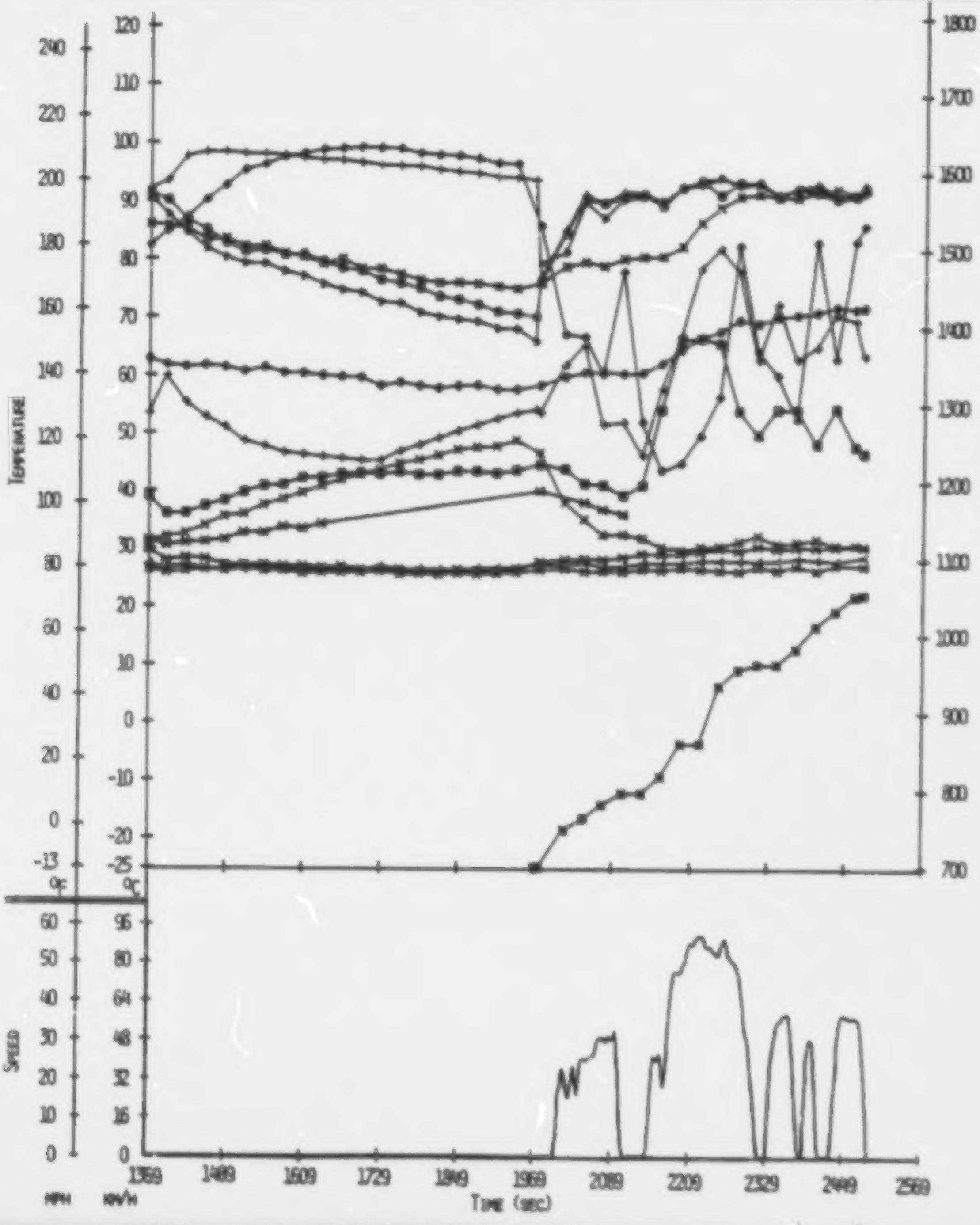
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⧗ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⊓ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
● — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 41

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING   TEST NO: 1.1.2-3   TEST TEMPERATURE: 25 C

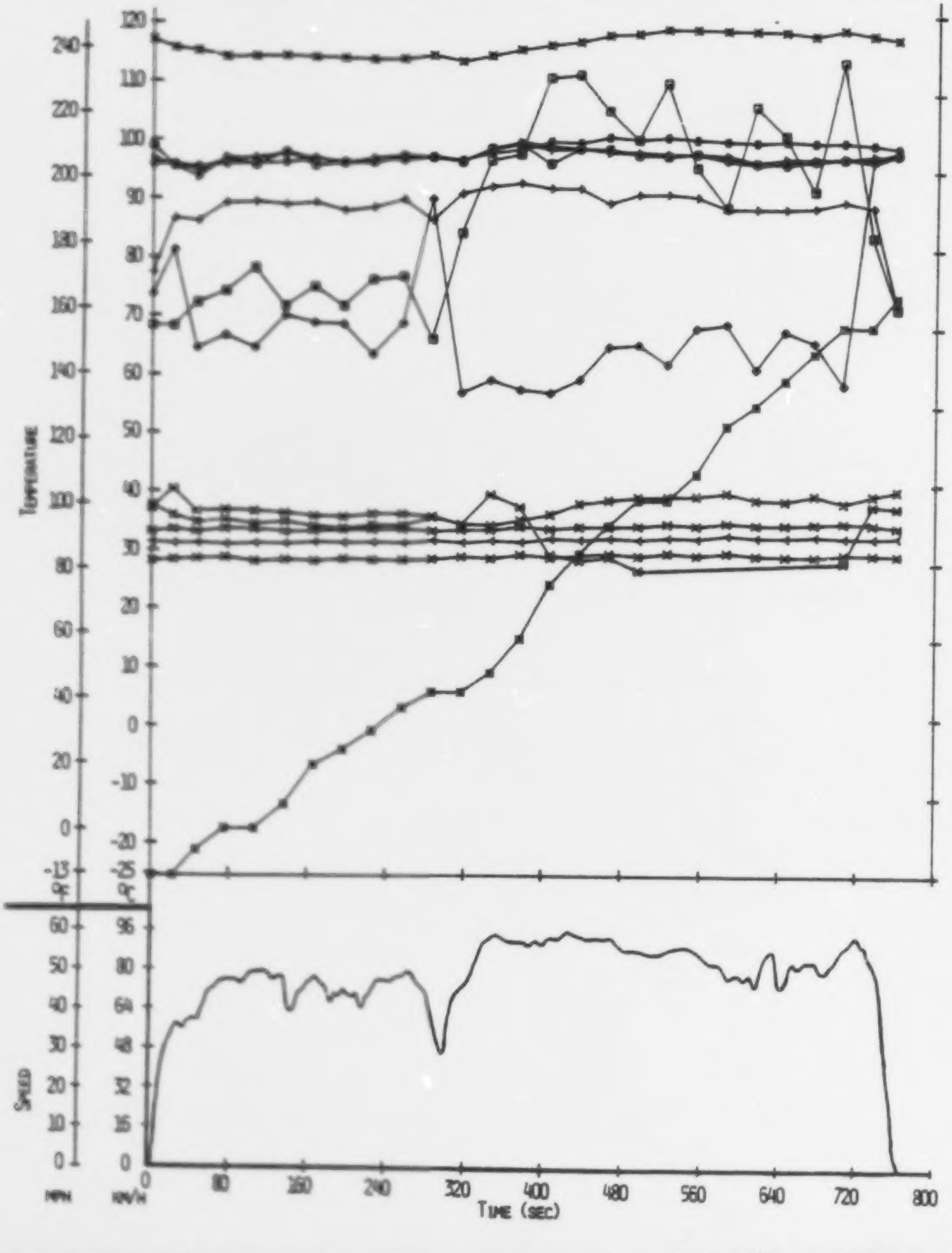
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✣ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✥ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ᛗ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 42**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.2-2 TEST TEMPERATURE: 25 C

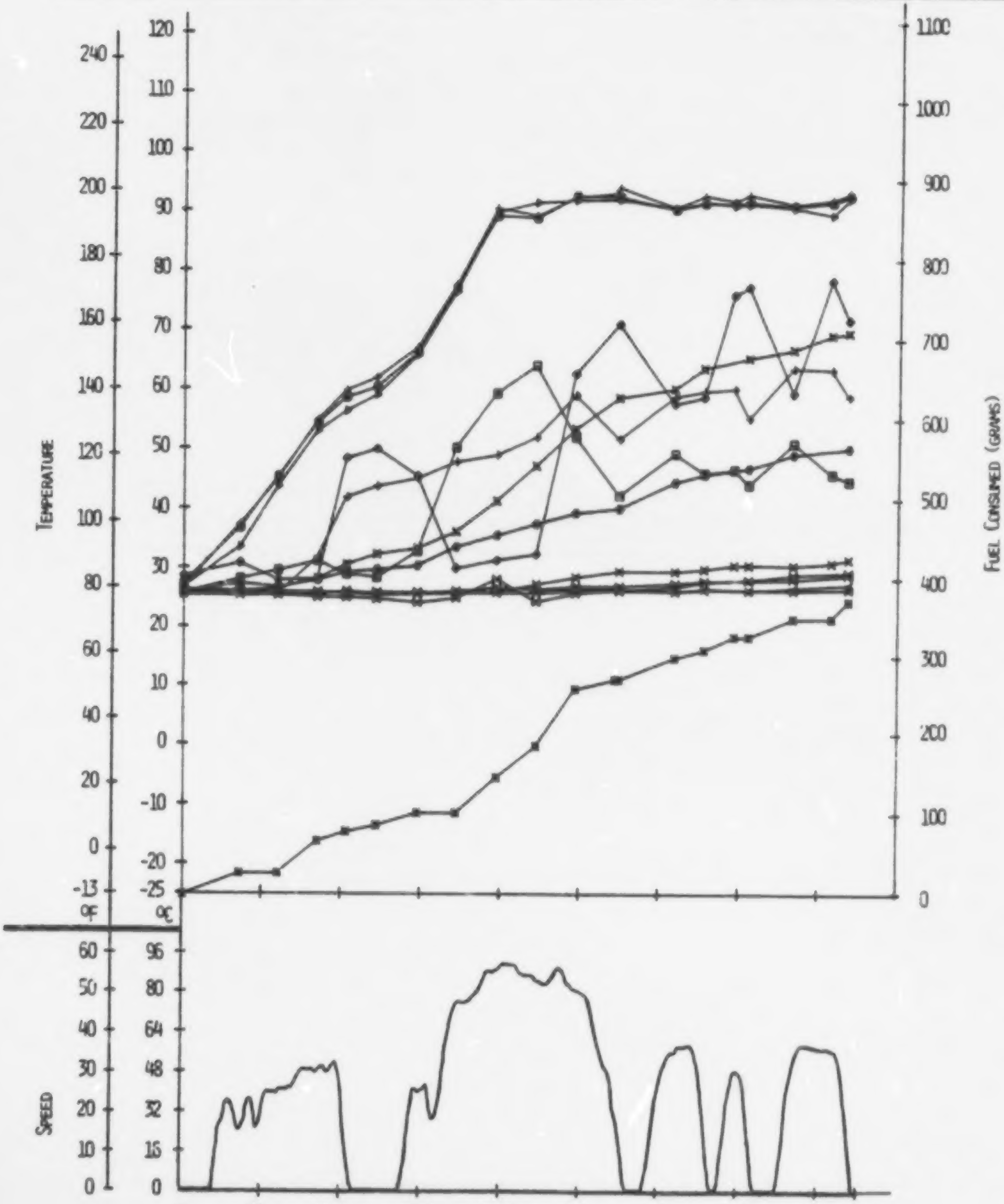
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⌘ — Eng. Oil @ Dipstick
⊗ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 43**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: **1.2.2-2** TEST TEMPERATURE: **25**

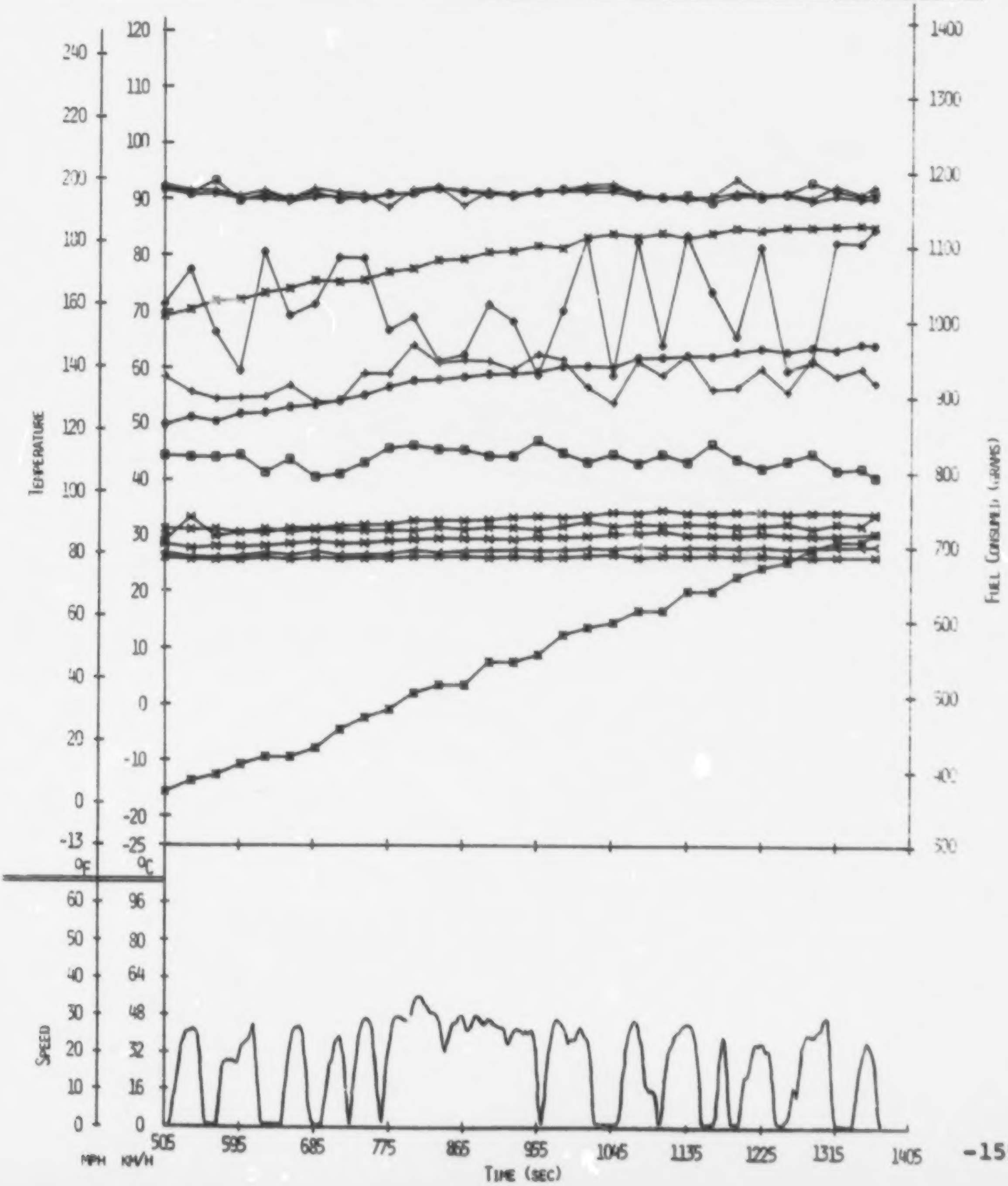
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **WITH OPTIMUM COLD SPARK TIMING**

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
+ — Coolant - Lower Rad. Hos
◇ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
□ — Stove Output
□ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
A — In Car Temp.
⋈ — Fuel In - Carb. Bowl
● — Fuel Consumed (Grams



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 44**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.2-2 TEST TEMPERATURE: 25 C

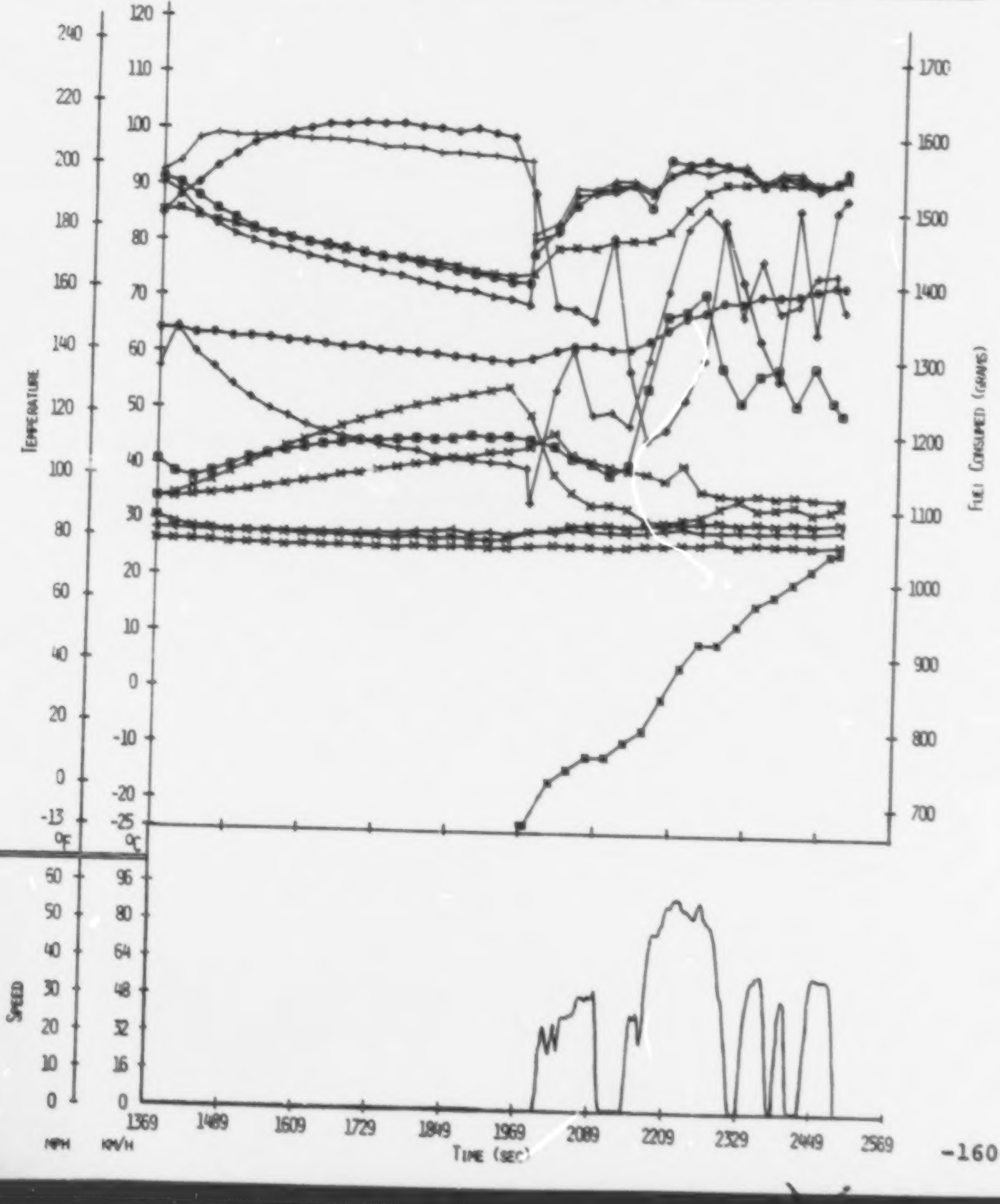
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION:WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
- + — Coolant - Thermostat
- ✚ — Coolant - Lower Rad. Hose
- ⊙ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⊡ — Stove Output
- ⊼ — Eng. Oil @ Dipstick
- ● — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel In - Carb. Bowl
- ● — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 45**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.2-2 TEST TEMPERATURE: 25 C

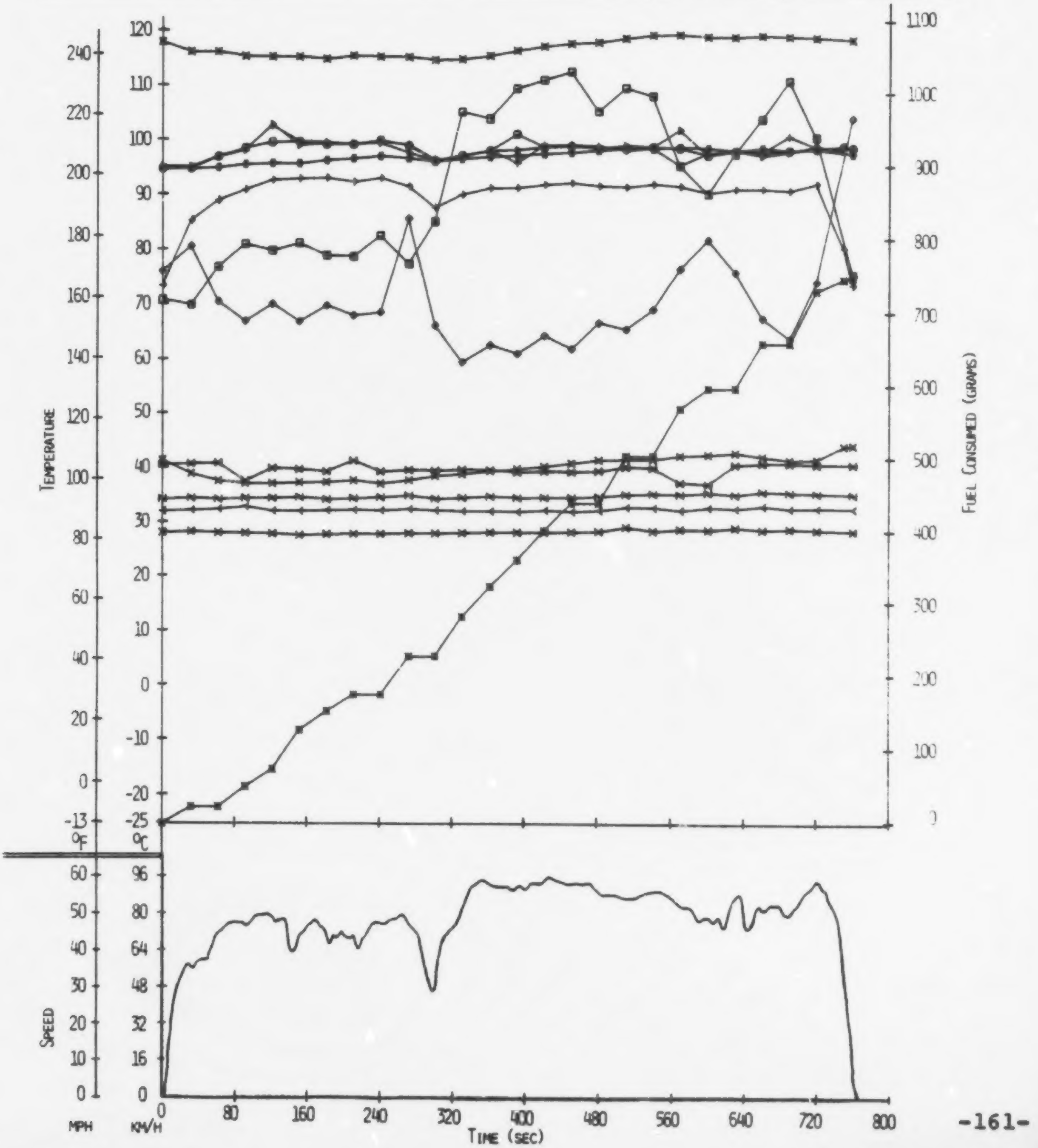
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 FGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
ʼn — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ⵍ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 46

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.3-2 TEST TEMPERATURE: 0 C

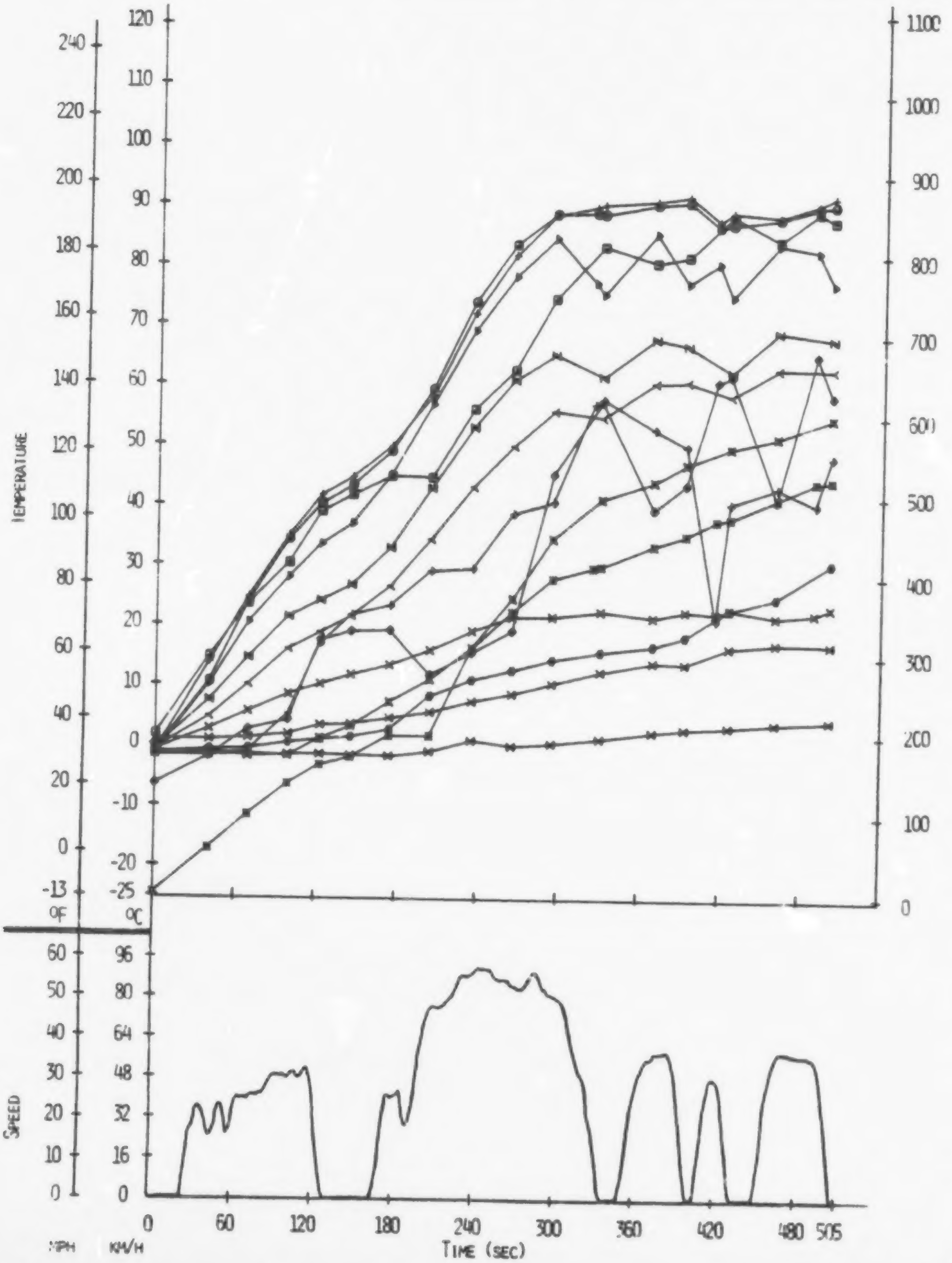
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
- + — Coolant - Thermostat
- ⊕ — Coolant - Lower Rad. Hose
- ⊙ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⊡ — Stove Output
- ⊓ — Eng. Oil @ Dipstick
- ● — Trans. Oil @ Dipstick
- < — Heater Duct - Left
- N — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel In - Carb. Bowl
- * — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 47**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.3-2 TEST TEMPERATURE: 0 C

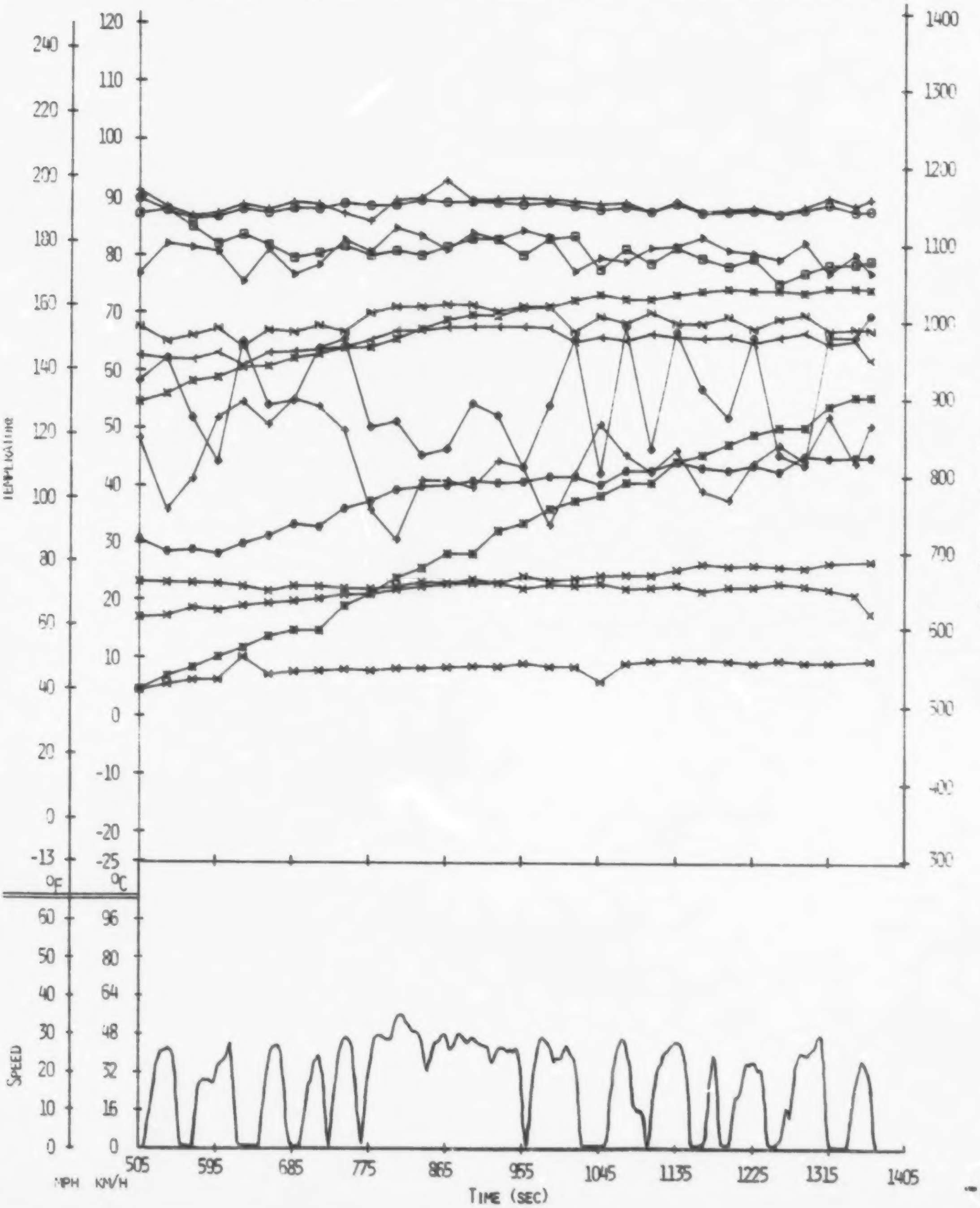
CITY CYCLE COLD STABILIZED TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **BASE VEHICLE**

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
□ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 48

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING   TEST NO: 1.1.3-2   TEST TEMPERATURE: 0 C

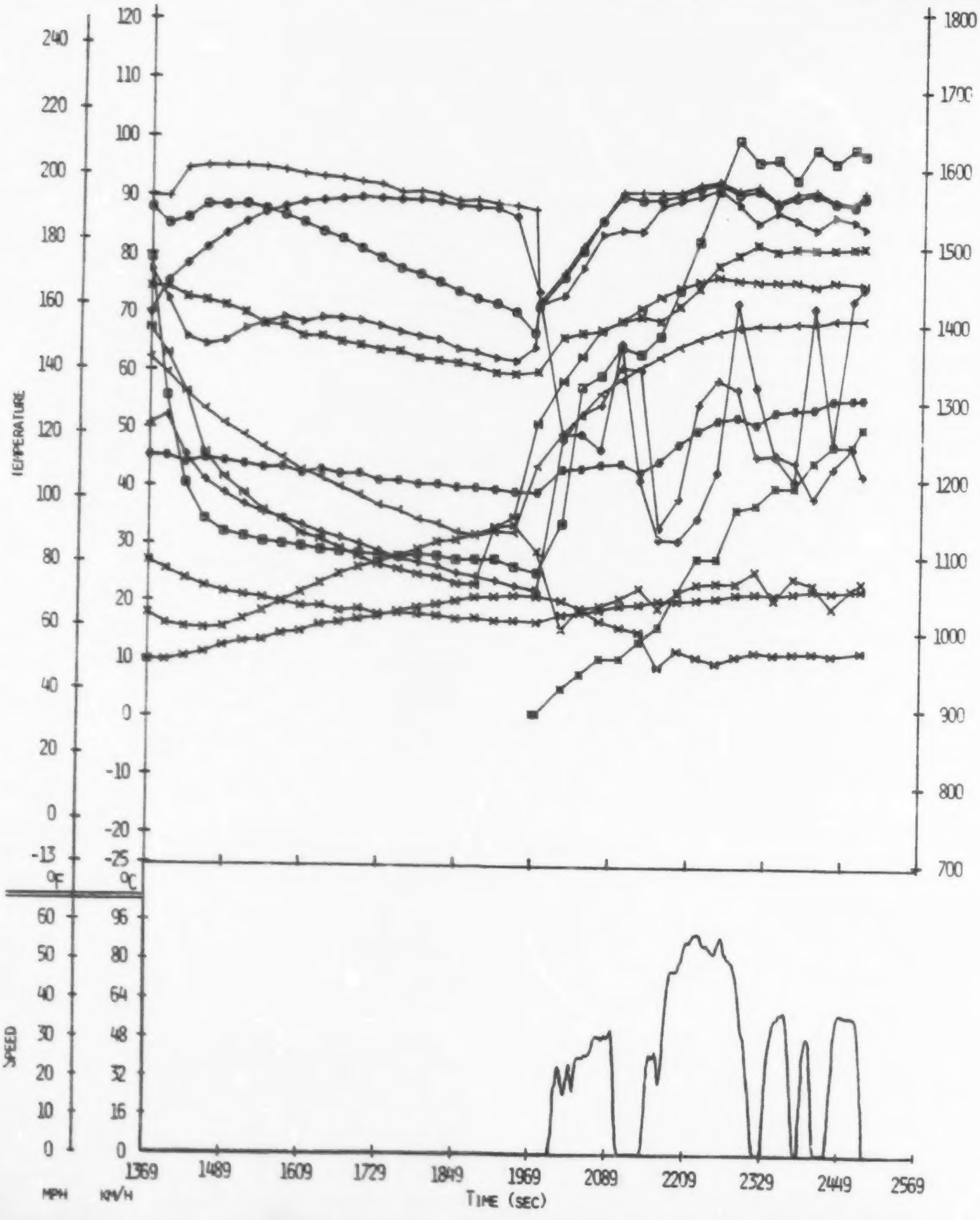
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
ℵ — Eng. Oil @ Dipstick
✤ -- Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 49**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.3-2 TEST TEMPERATURE: 0 C

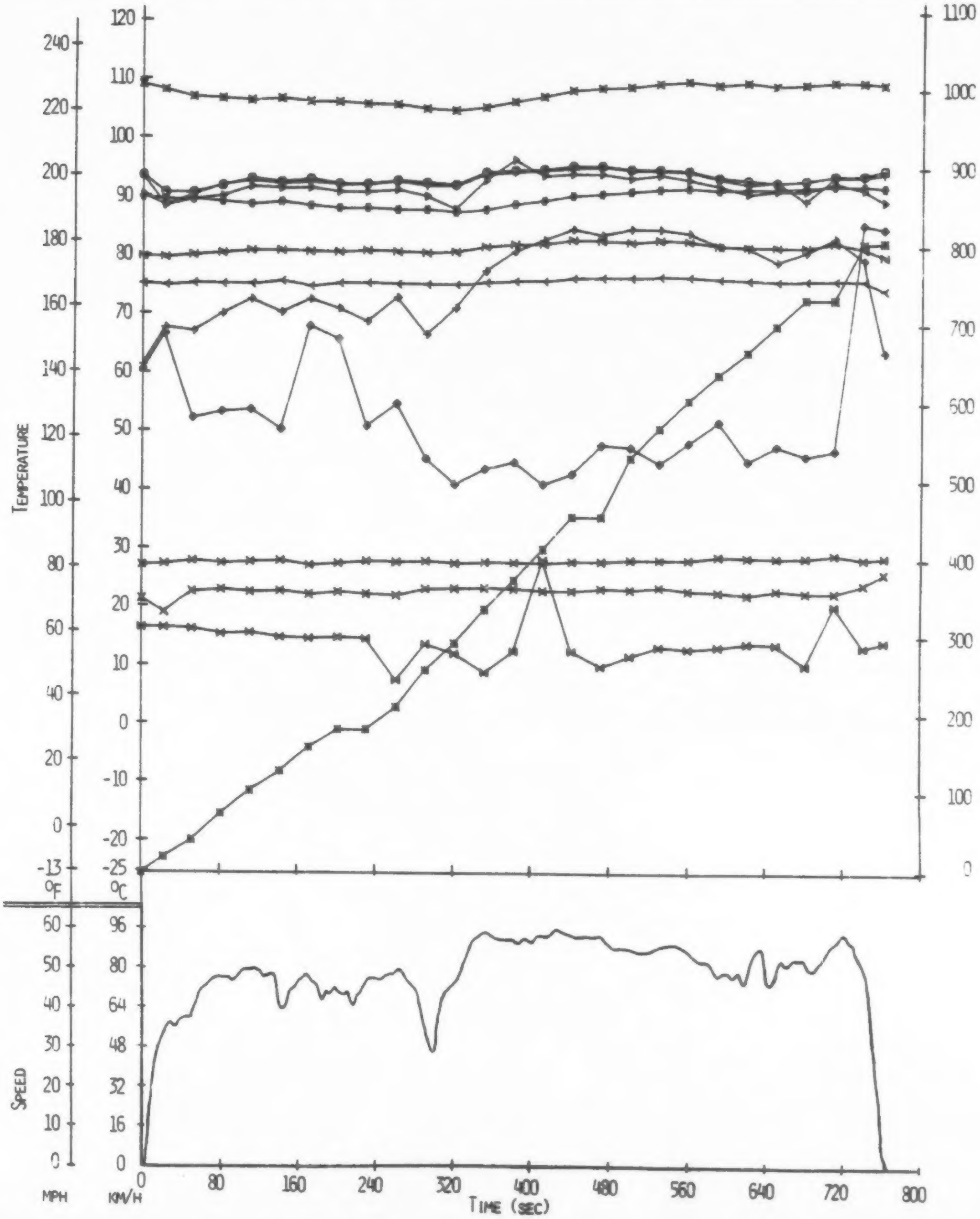
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
➔ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⊓ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 50

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.3-3 TEST TEMPERATURE: 0 C

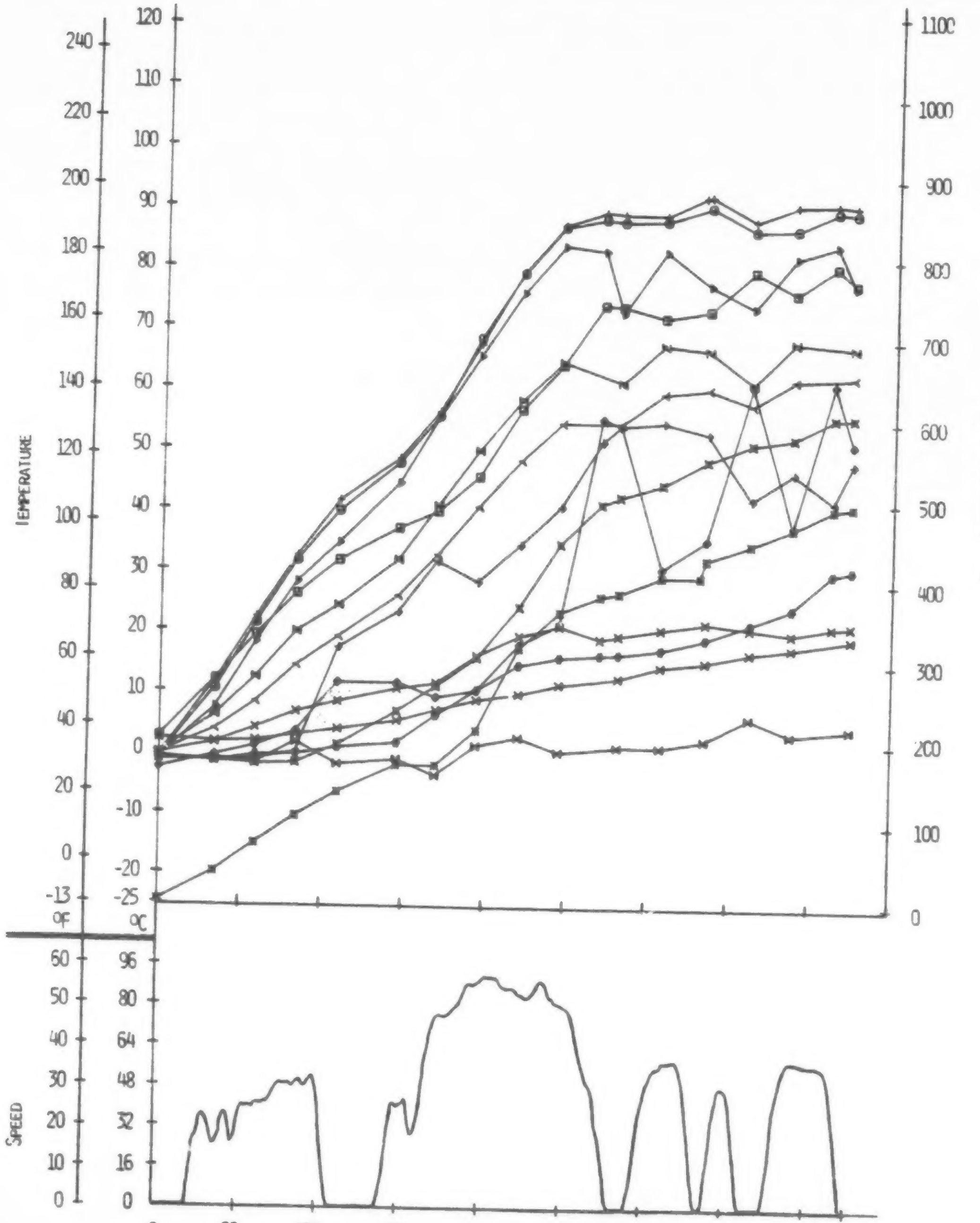
CITY CYCLE COLD TRANSIENT TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 FGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
ℵ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 51**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: **1.2.3-3** TEST TEMPERATURE: **0** C

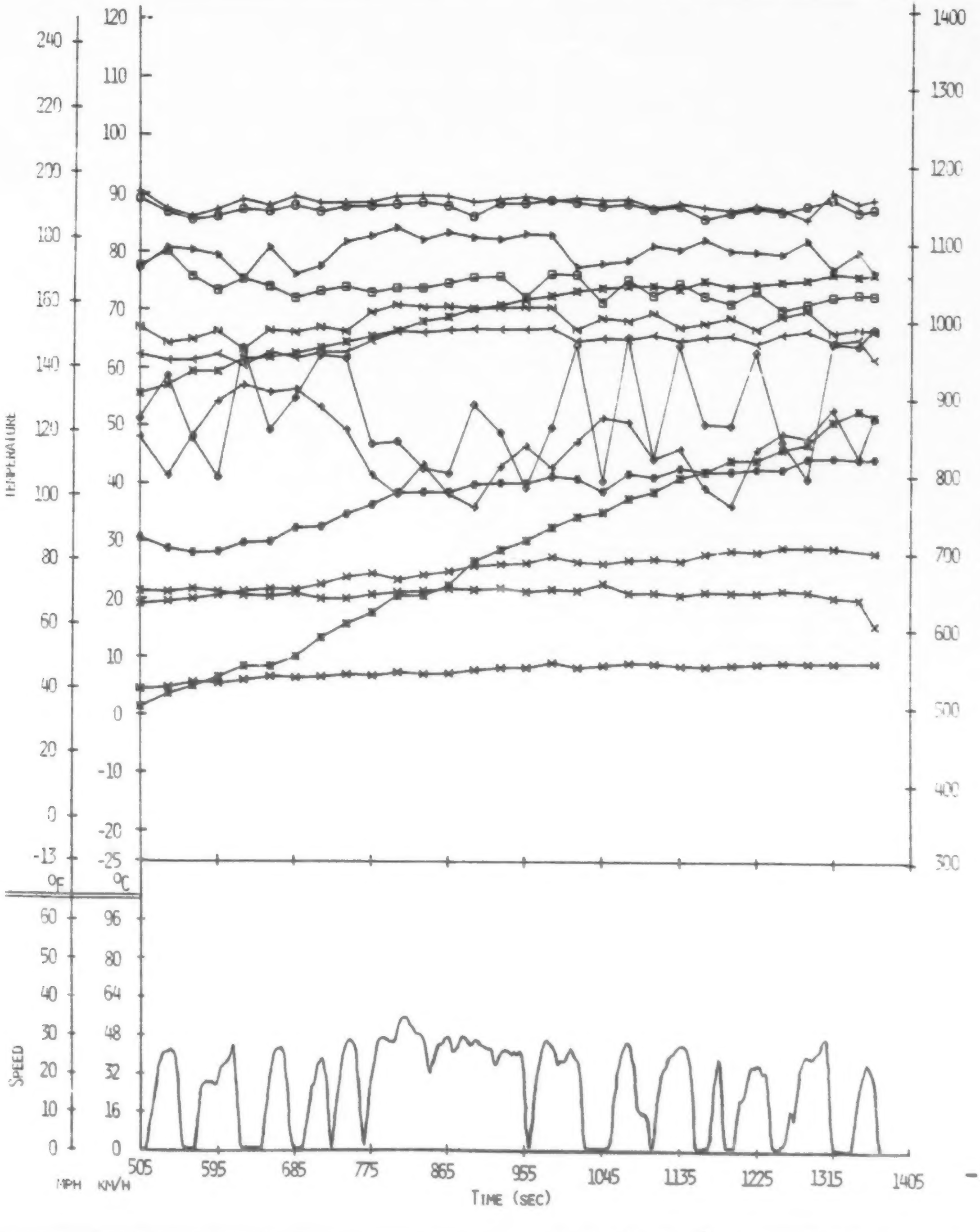
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **WITH OPTIMUM COLD SPARK TIMING**

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: **Tests** run **with** high volume cooling **fan**, **hood closed**, **and heater controls and dyno** H.P. **setting adjusted for** test **temperature.**

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
+ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊞ — Stove Output
♮ — Eng. Oil @ Dipstick
⊕ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 52**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.3-3 TEST TEMPERATURE: 0 C

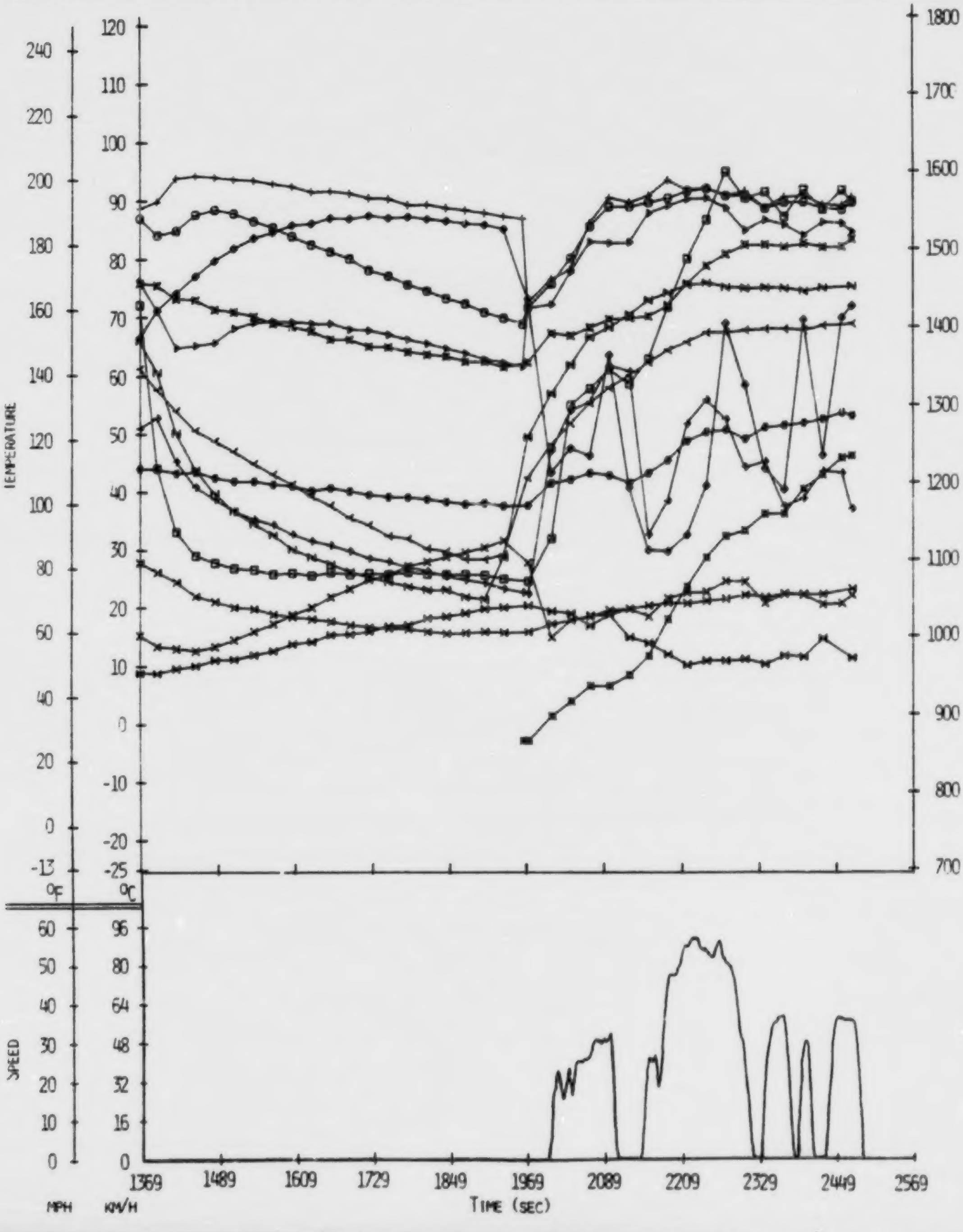
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
π — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 53

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING   TEST NO: 1.2.3-3   TEST TEMPERATURE: 0 C

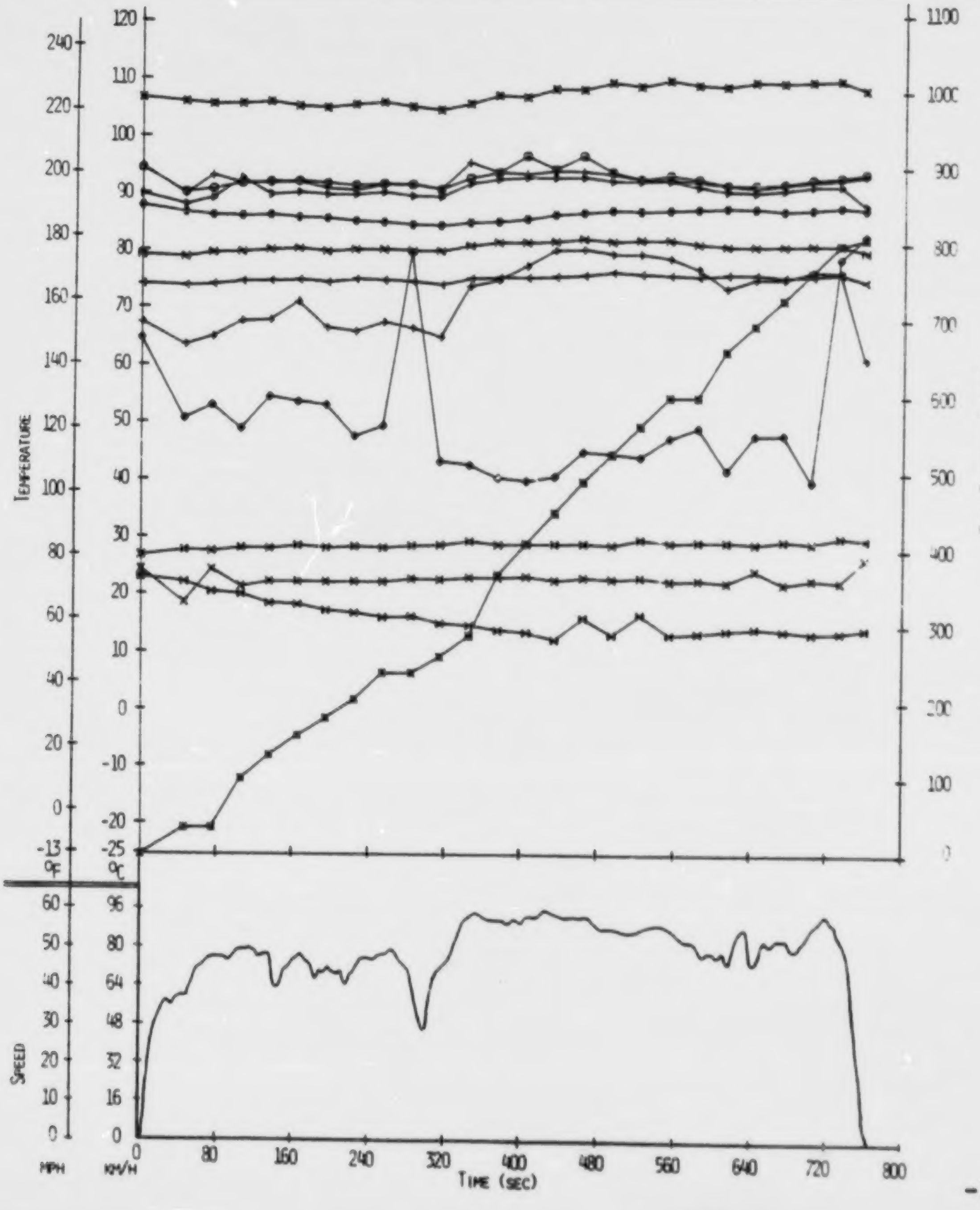
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊣ — Stove Output
⋈ — Eng. Oil @ Dipstick
⚙ — Trans. Oil @ Dipstick
< — Heater Duct - Left
⊠ — Heater Duct - Right
⊠ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 54

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.4-8 TEST TEMPERATURE: -20 C

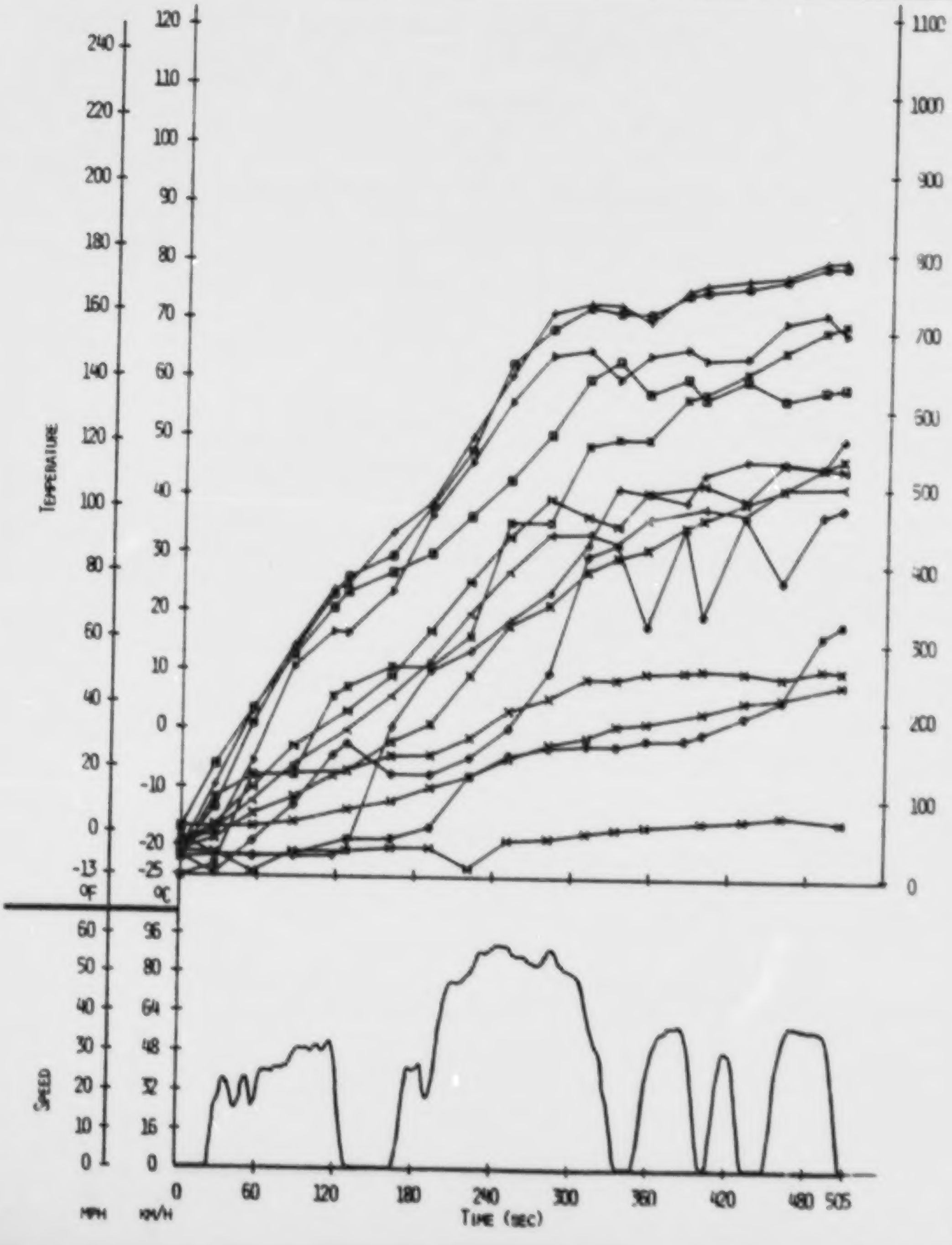
CITY CYCLE COLD TRANSIENT TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
• — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 55**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.4-8 TEST TEMPERATURE: -20 C

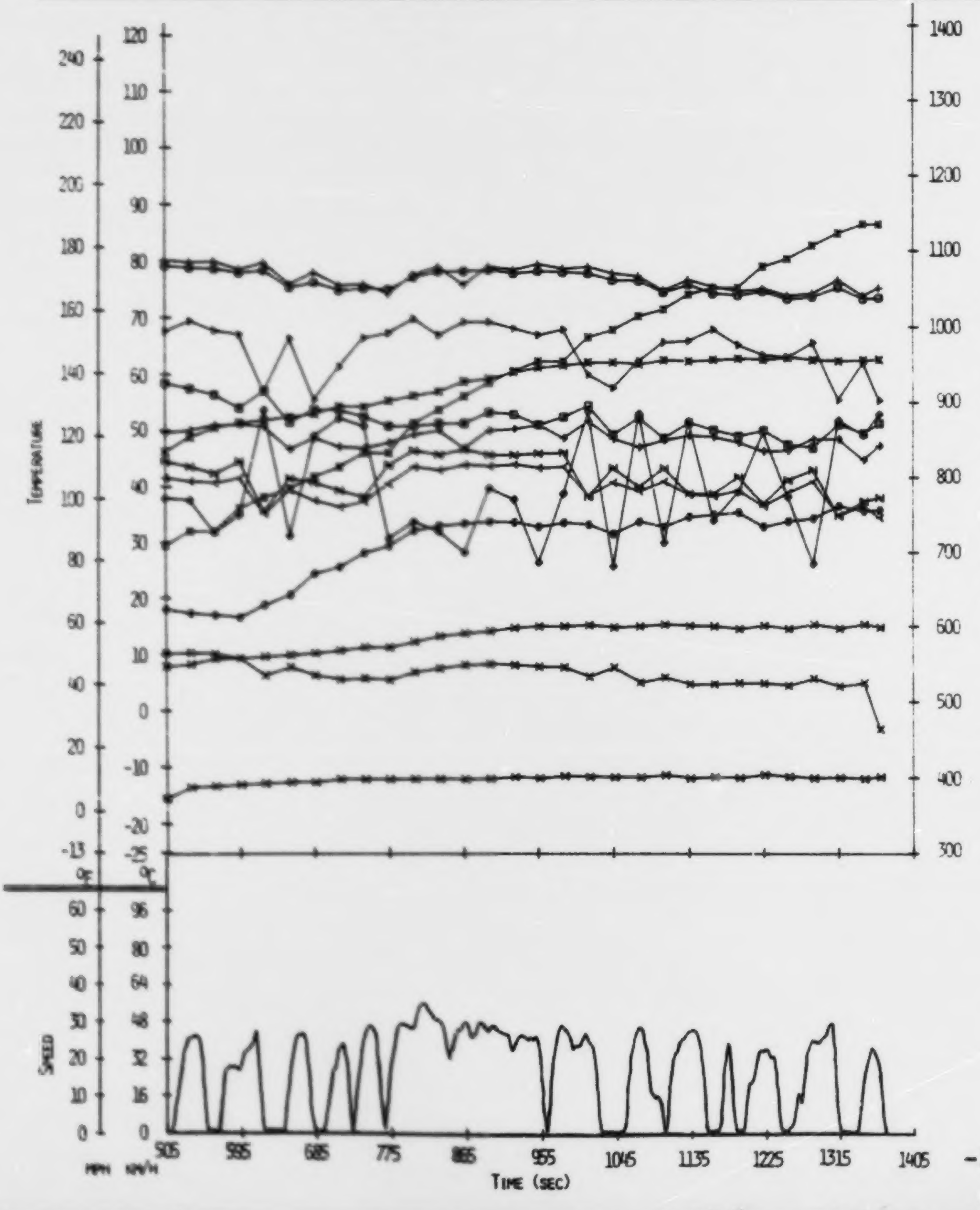
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
G — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 56**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.4-8 TEST TEMPERATURE: -20 C

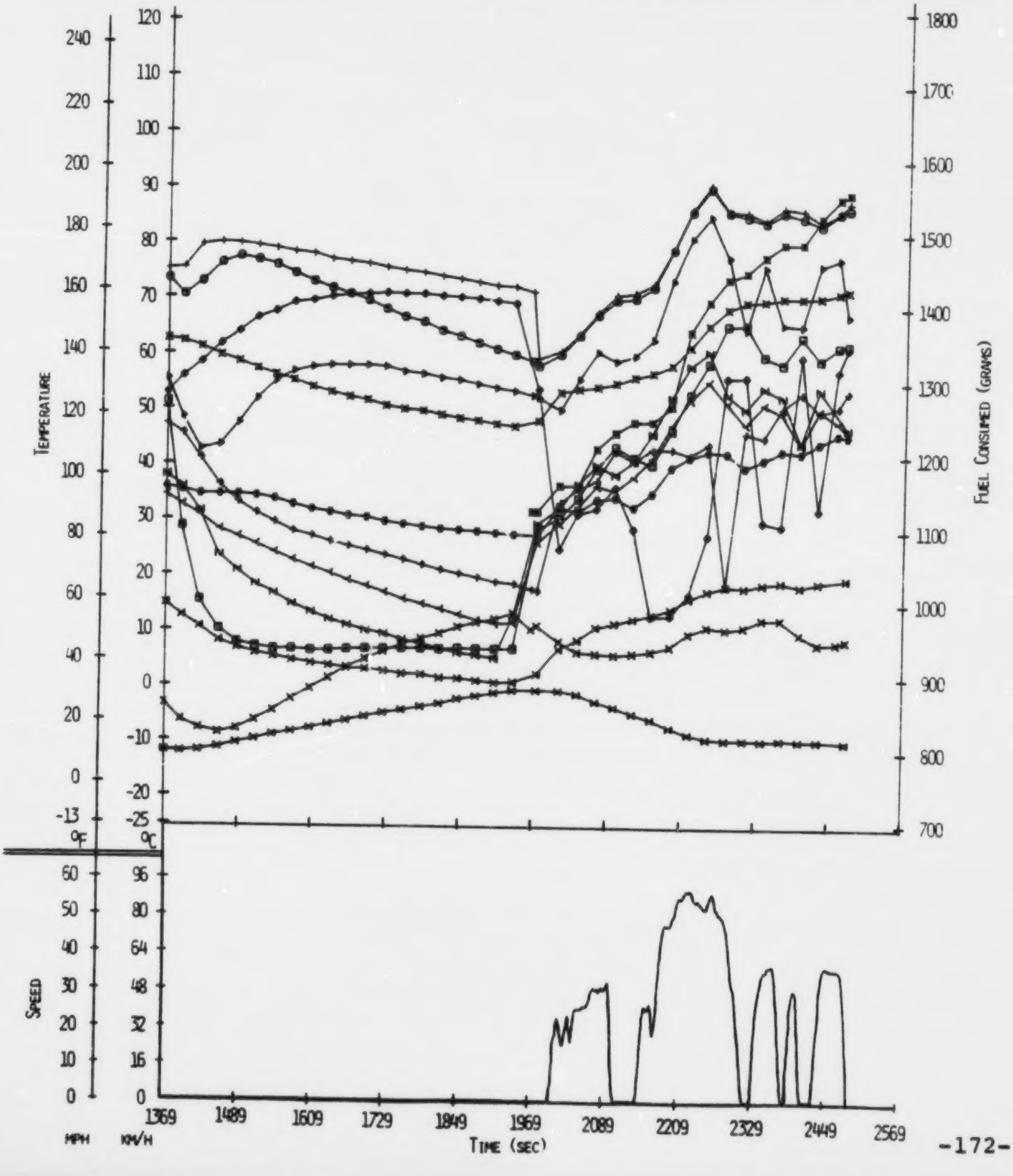
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
- + — Coolant - Thermostat
- ➔ — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◈ — Int. Manifold Runner
- ⊟ — Stove Output
- ⌑ — Eng. Oil @ Dipstick
- ✱ — Trans. Oil @ Dipstick
- < — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel In - Carb. Bowl
- * — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 57

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.1.4-8 TEST TEMPERATURE: -20 C

HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION:BASE VEHICLE

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)

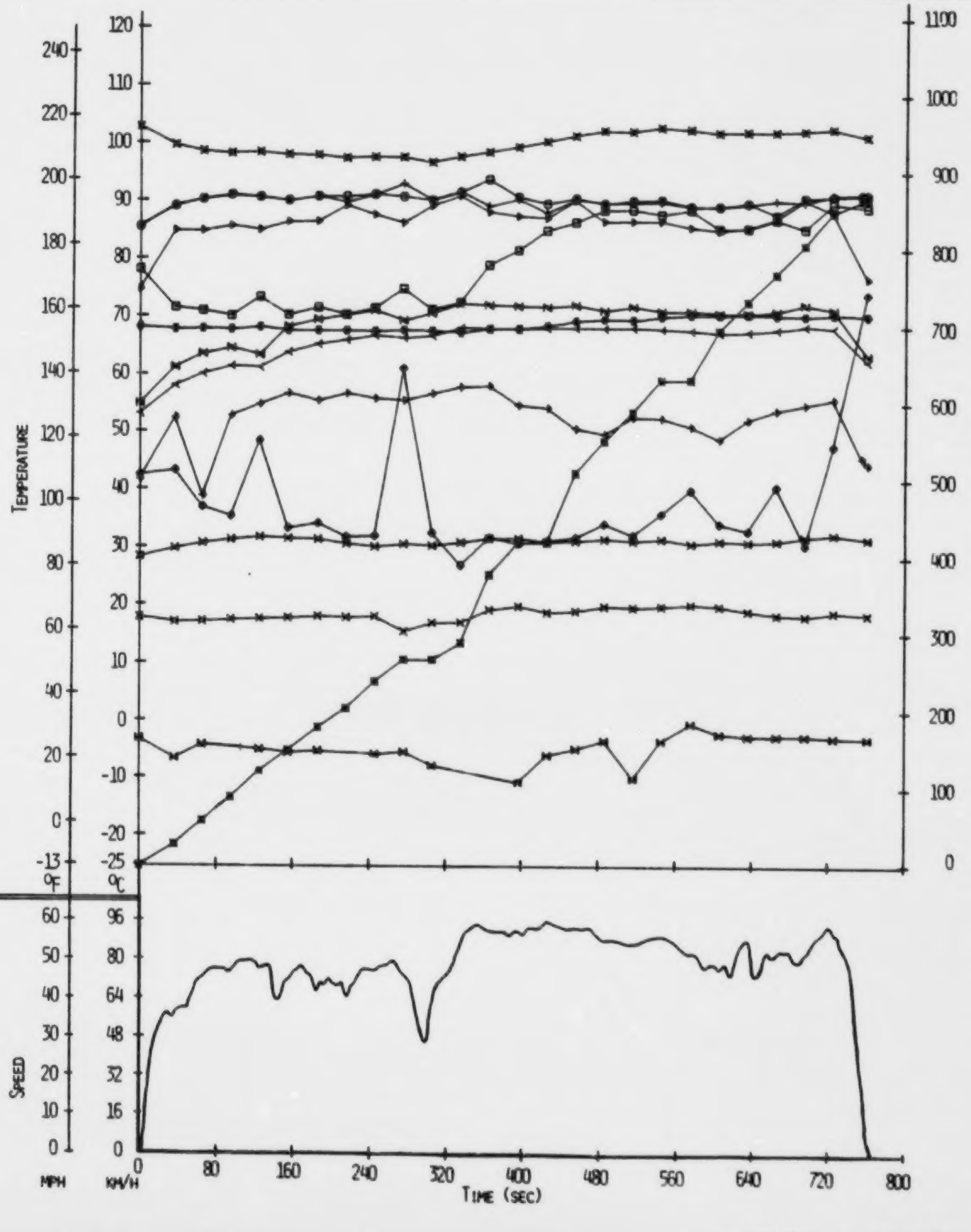


Figure 58

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.4-9 TEST TEMPERATURE: -20 C

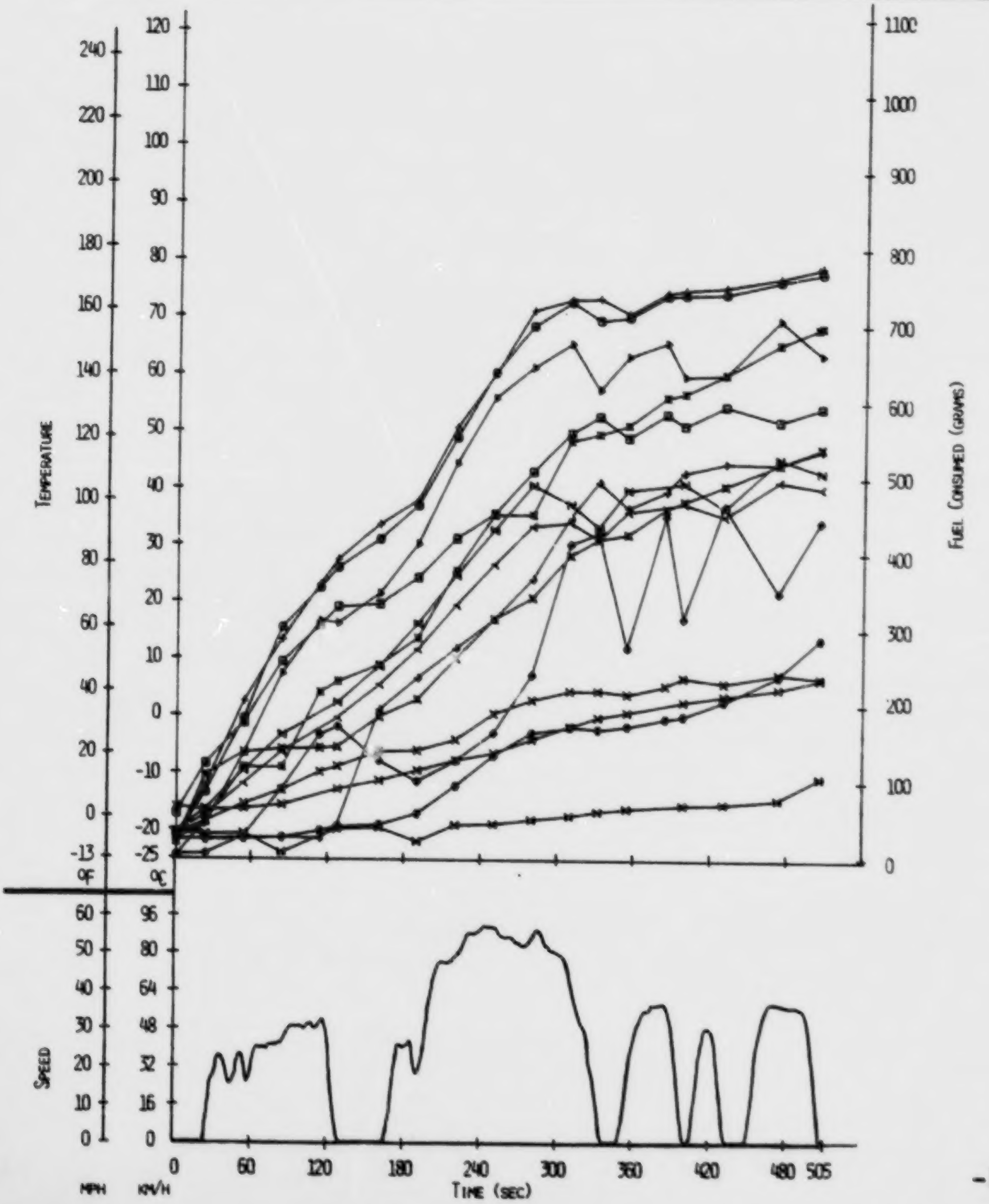
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 59**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.4-9 TEST TEMPERATURE: -20 C

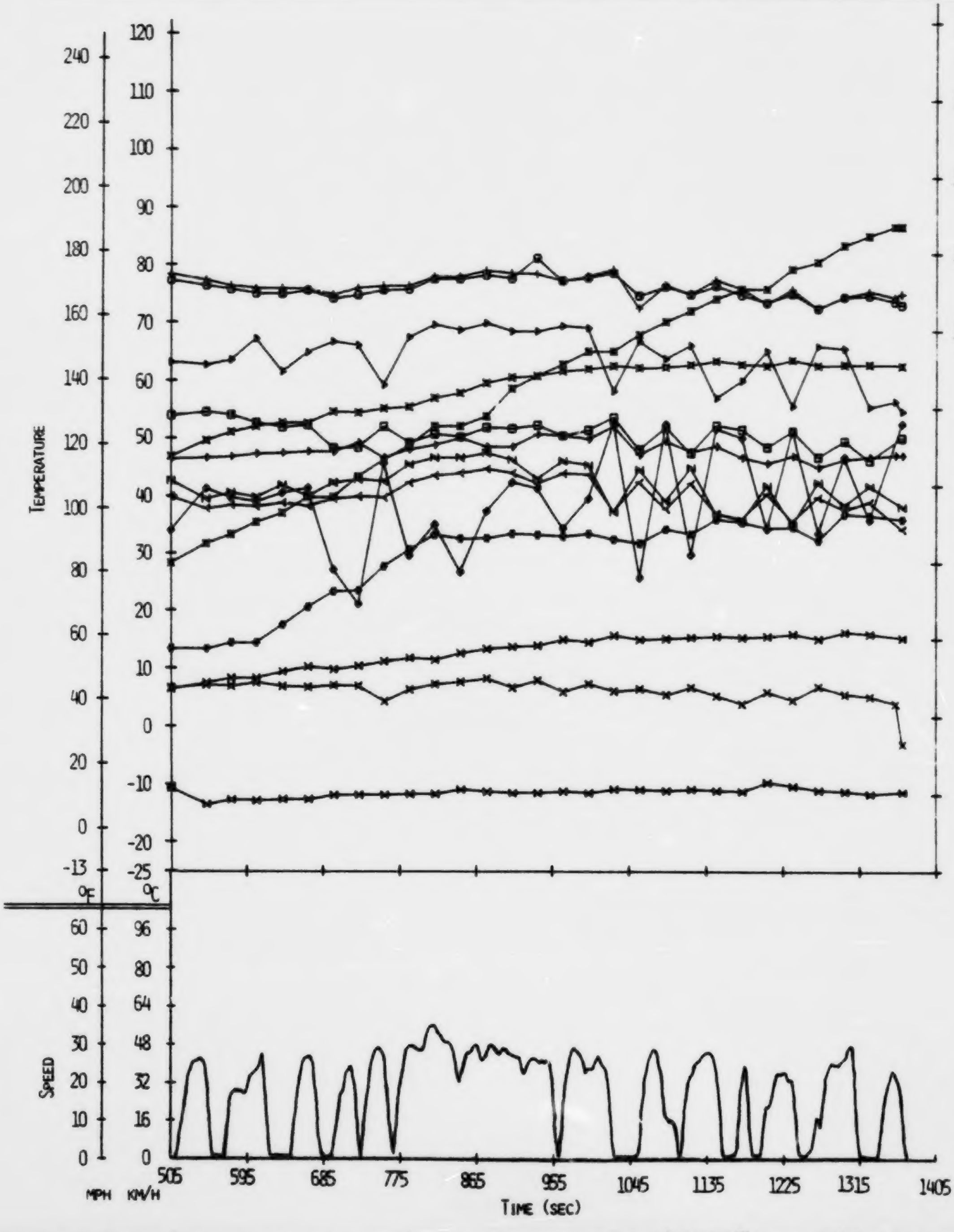
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
✦ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 60**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.4-9 TEST TEMPERATURE: -20 C

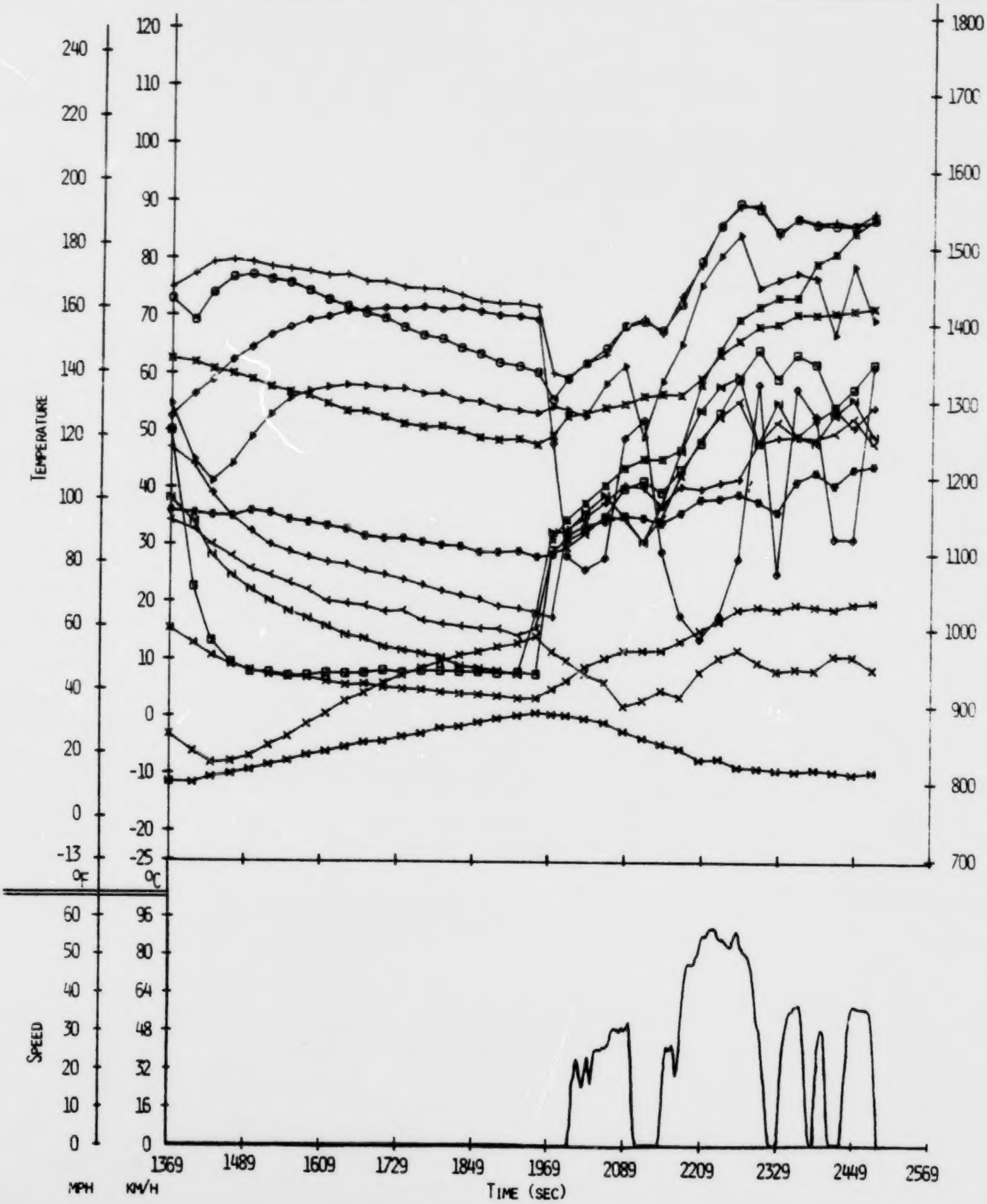
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION:WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
✪ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 61**

VEHICLE NUMBER: 1 OPTIMUM COLD TIMING TEST NO: 1.2.4-9 TEST TEMPERATURE: -20 C

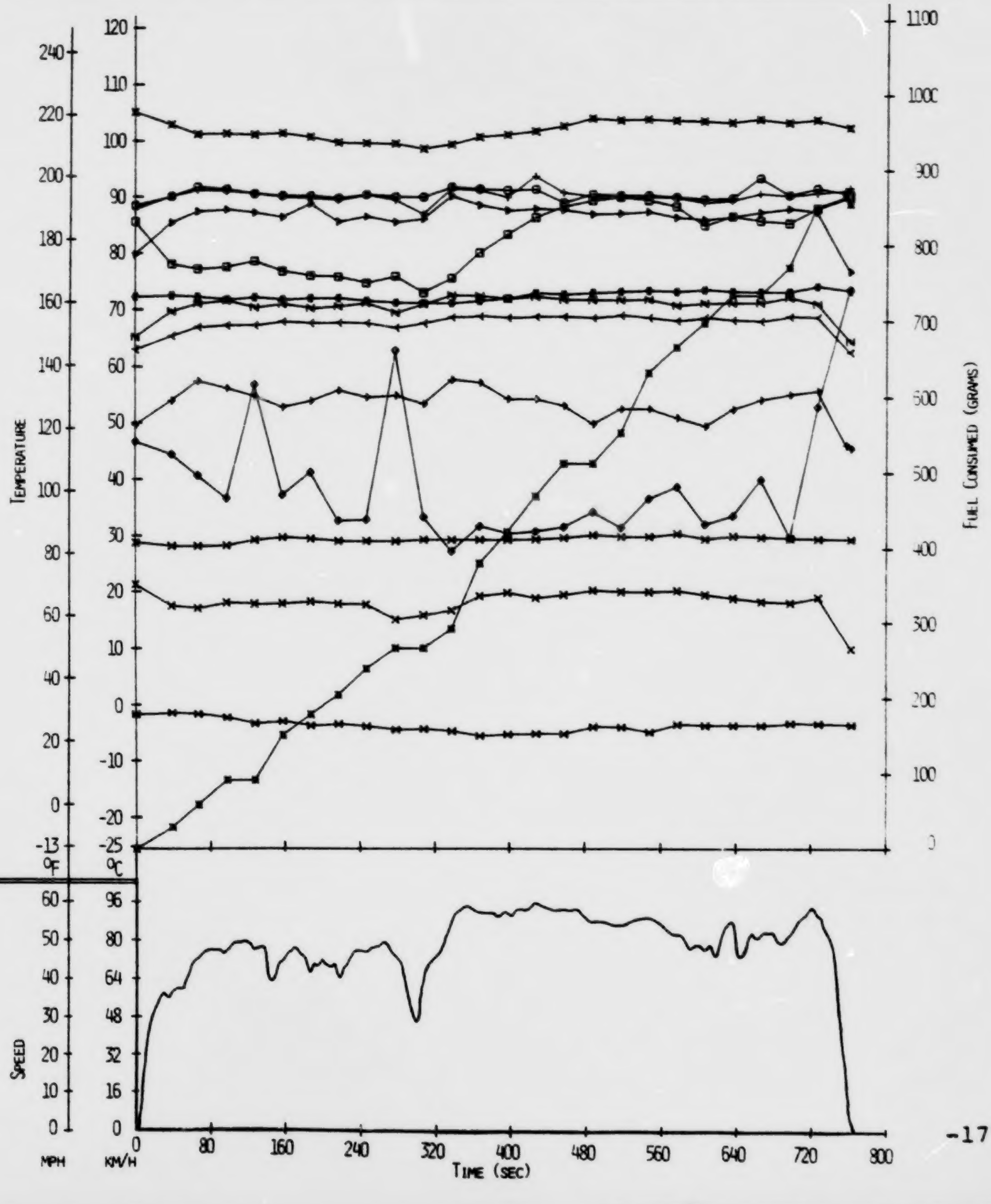
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH OPTIMUM COLD SPARK TIMING

Base Vehicle: 1980 'L' Car with 9.5:1 Comp. Ratio 1.7L Engine
1980 EGR & 1979 Carb. V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 1)
+ — Coolant - Thermostat
➔ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel In - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 62**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.2-3 TEST TEMPERATURE: 25 C

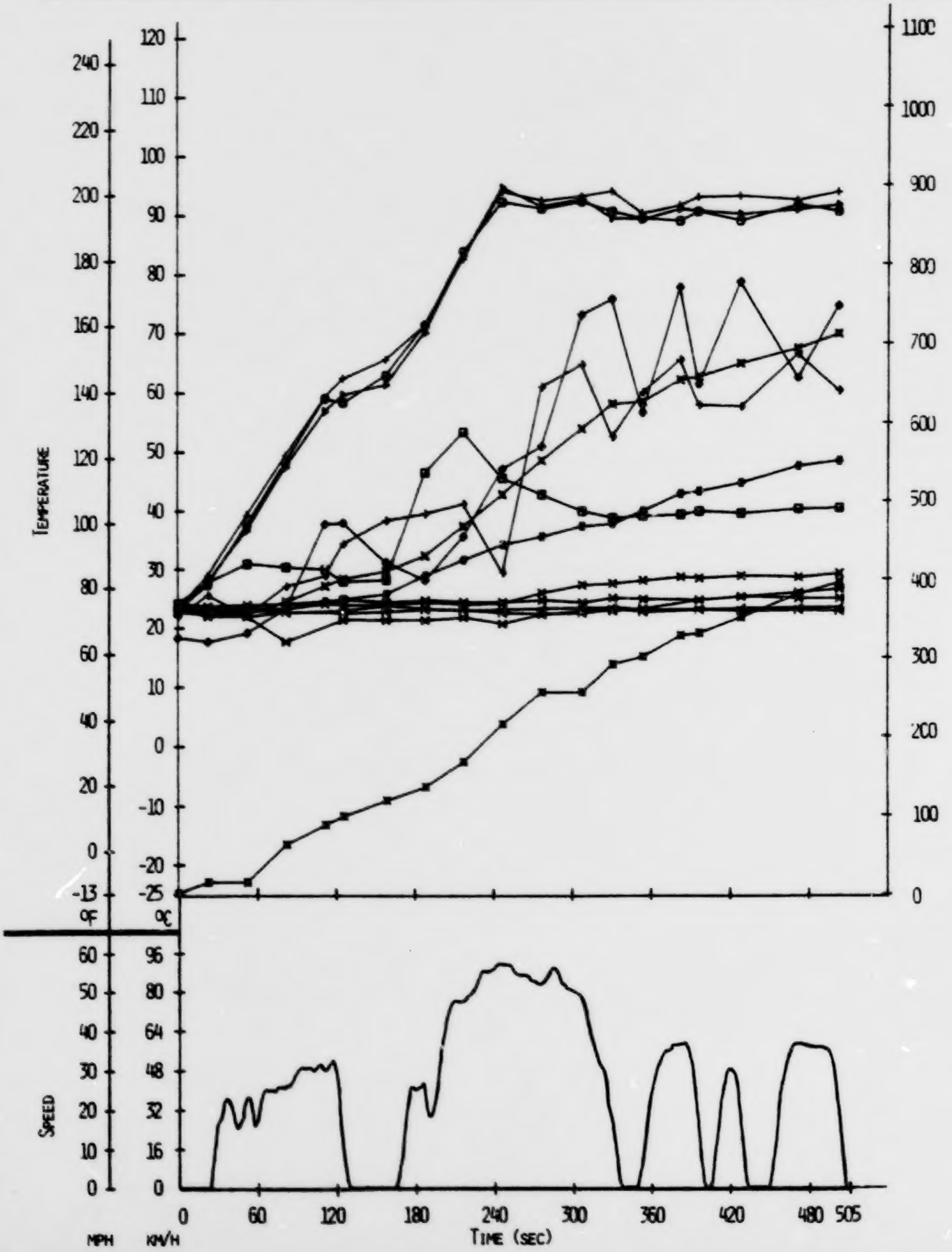
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
- + — Coolant - Thermostat
- ✦ — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- < — Carb. Air In
- ◇ — Int. Manifold Runner
- ⊟ — Stove Output
- ⌘ — Eng. Oil @ Dipstick
- ● — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- N — Heater Duct - Right
- ✕ — In Car Temp.
- ⋈ — Fuel in - Carb. Bowl
- ✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure** 63

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.2-3 TEST TEMPERATURE: 25 C

CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

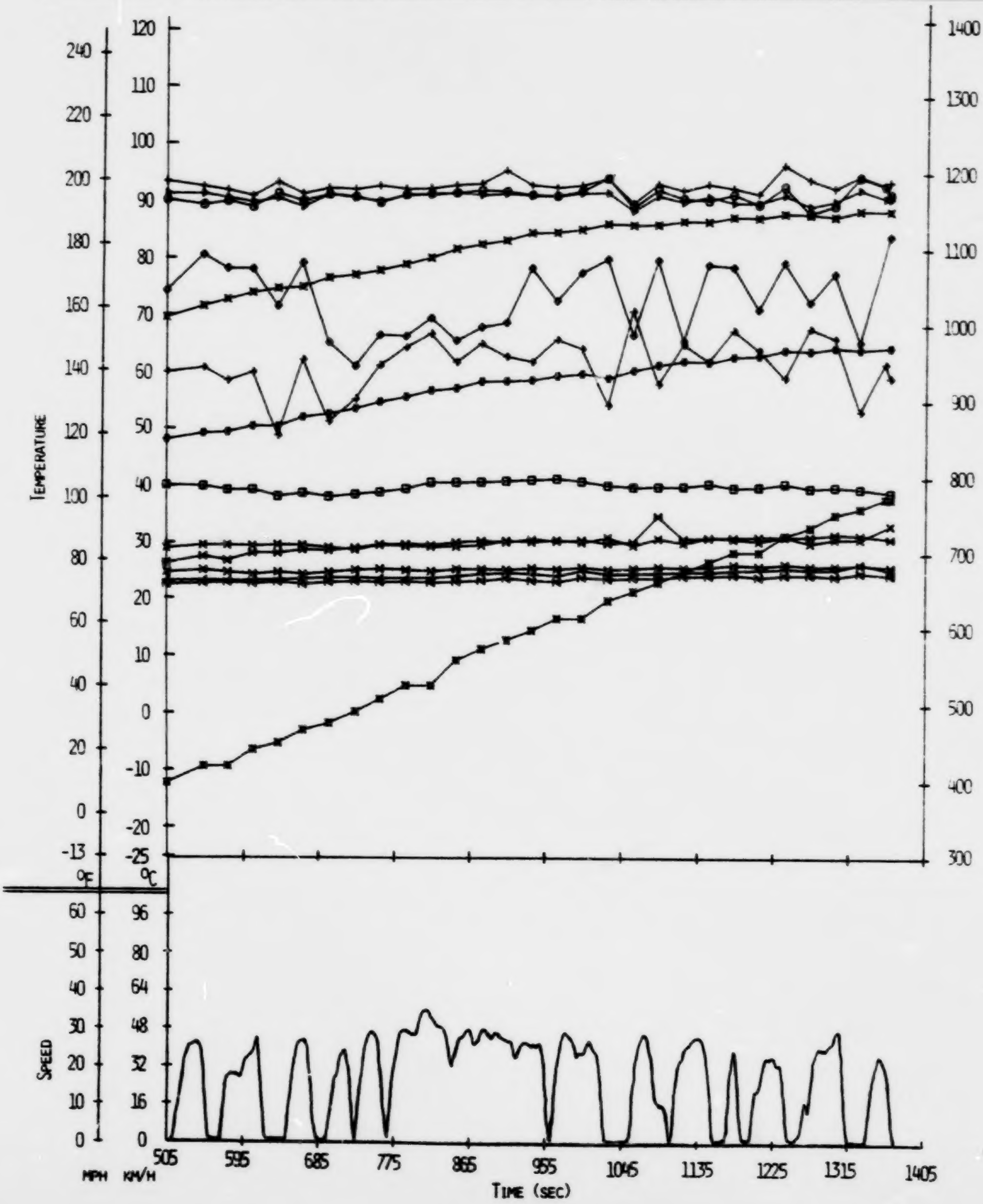
HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)

+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hos
⊖ — Coolant - Heater In
⊳ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌧ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 64**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.2-3 TEST TEMPERATURE: 25 C

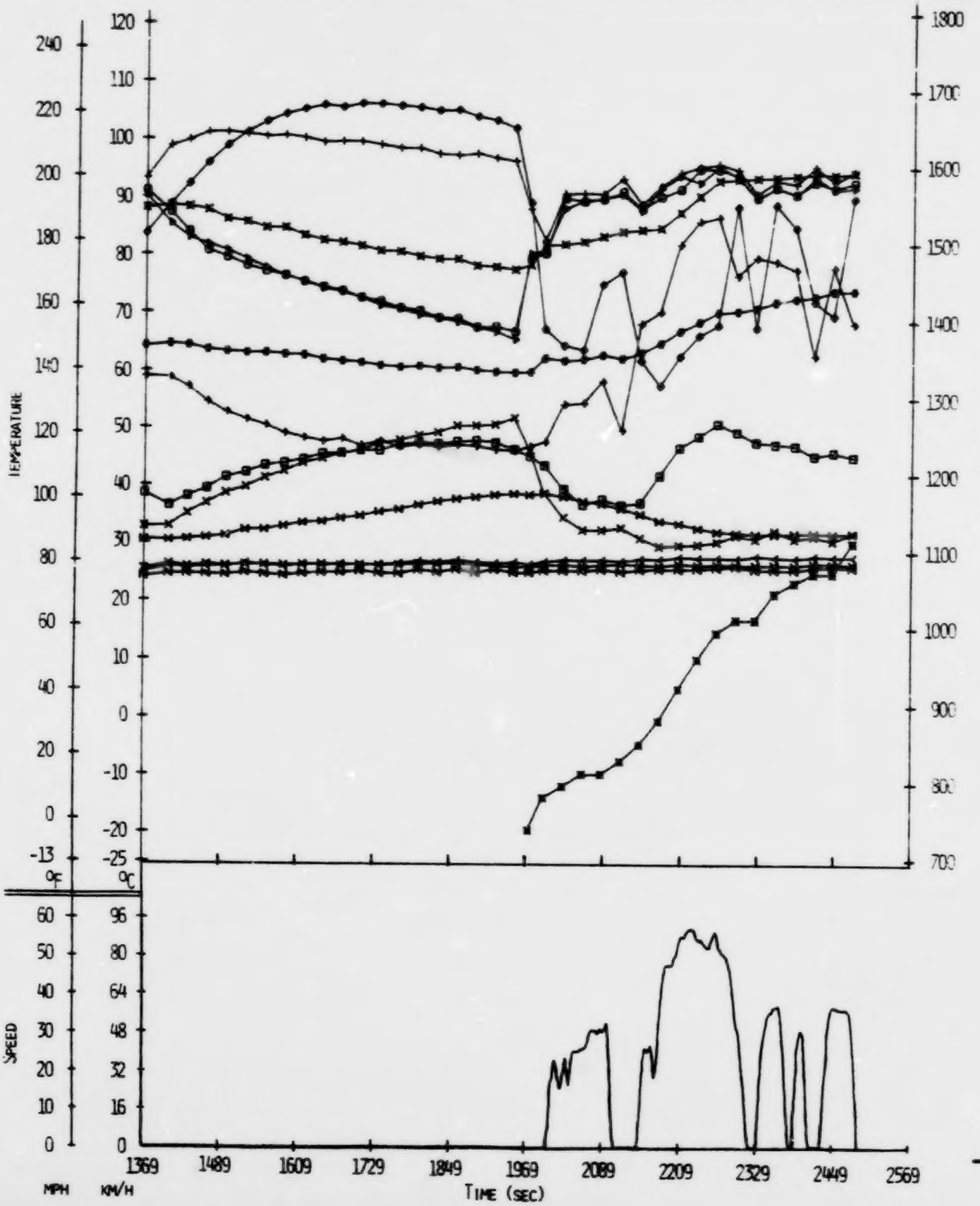
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✣ — Trans. Oil @ Dipstick
< — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 65

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: **3.1.2-3** TEST TEMPERATURE: **25** C

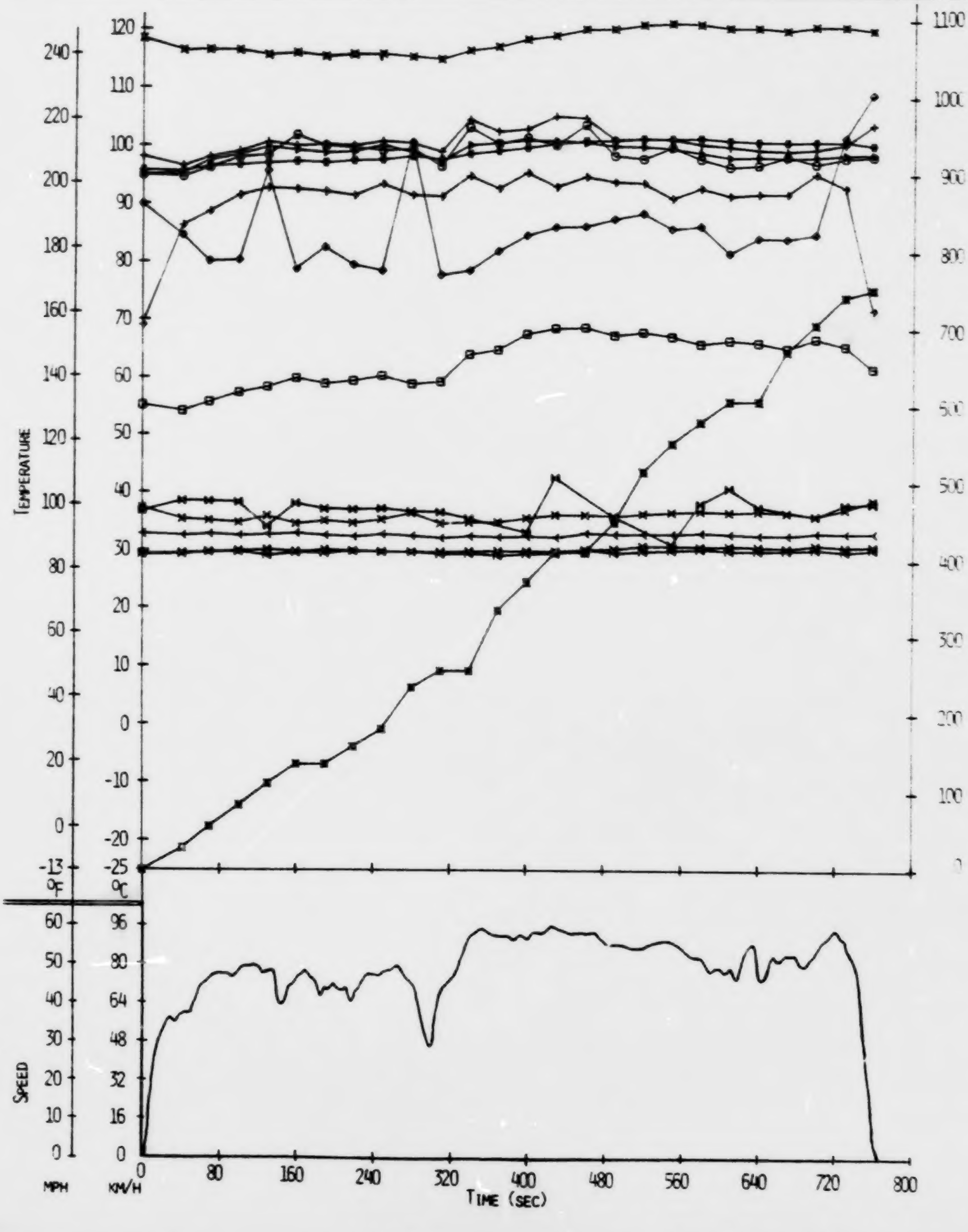
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **BASE VEHICLE**

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 66

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.2-2 TEST TEMPERATURE: 25 C

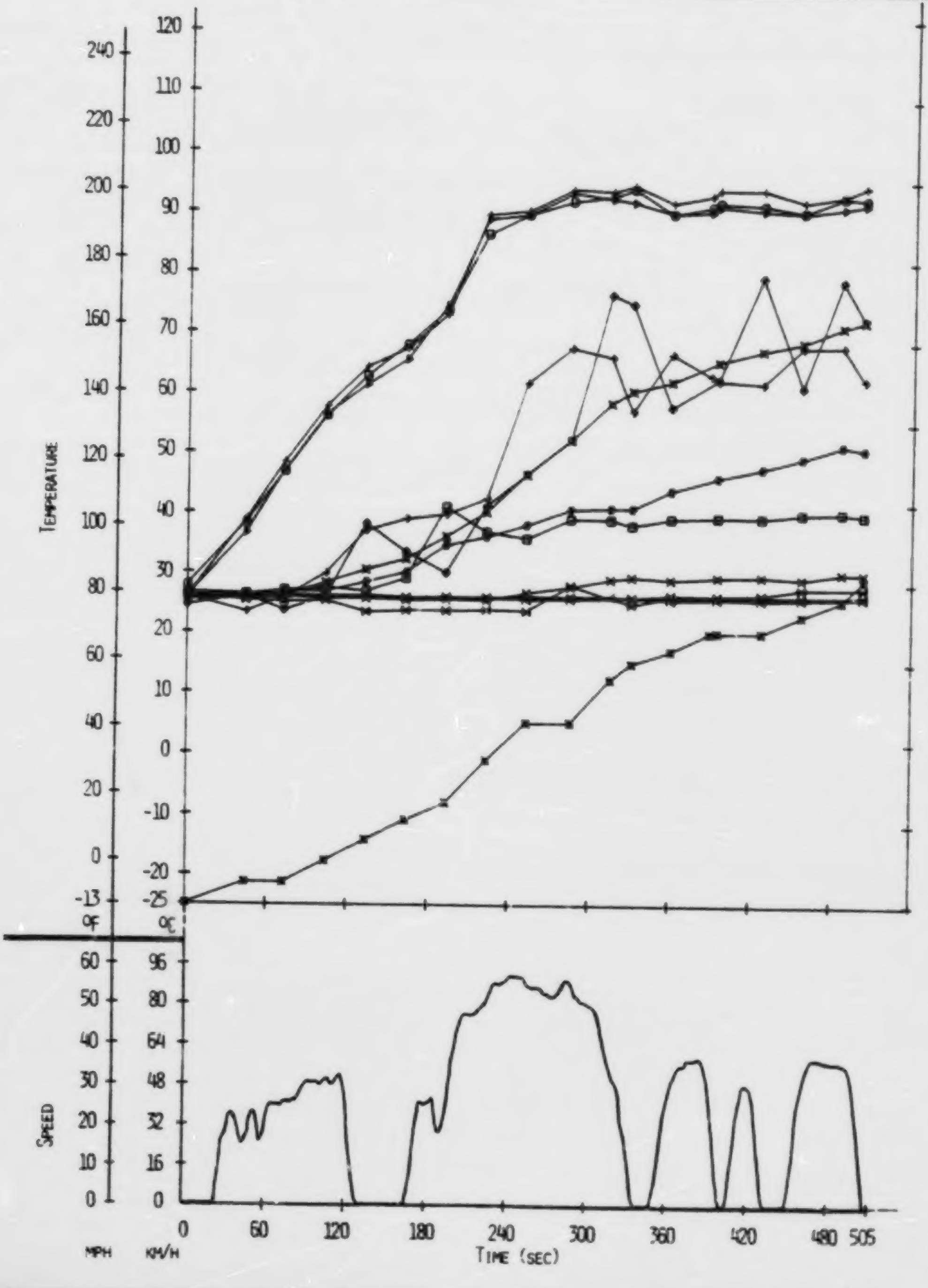
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
ʚ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◊ — Int. Manifold Runner
⊟ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
₪ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 67**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.2-2 TEST TEMPERATURE: 25 C

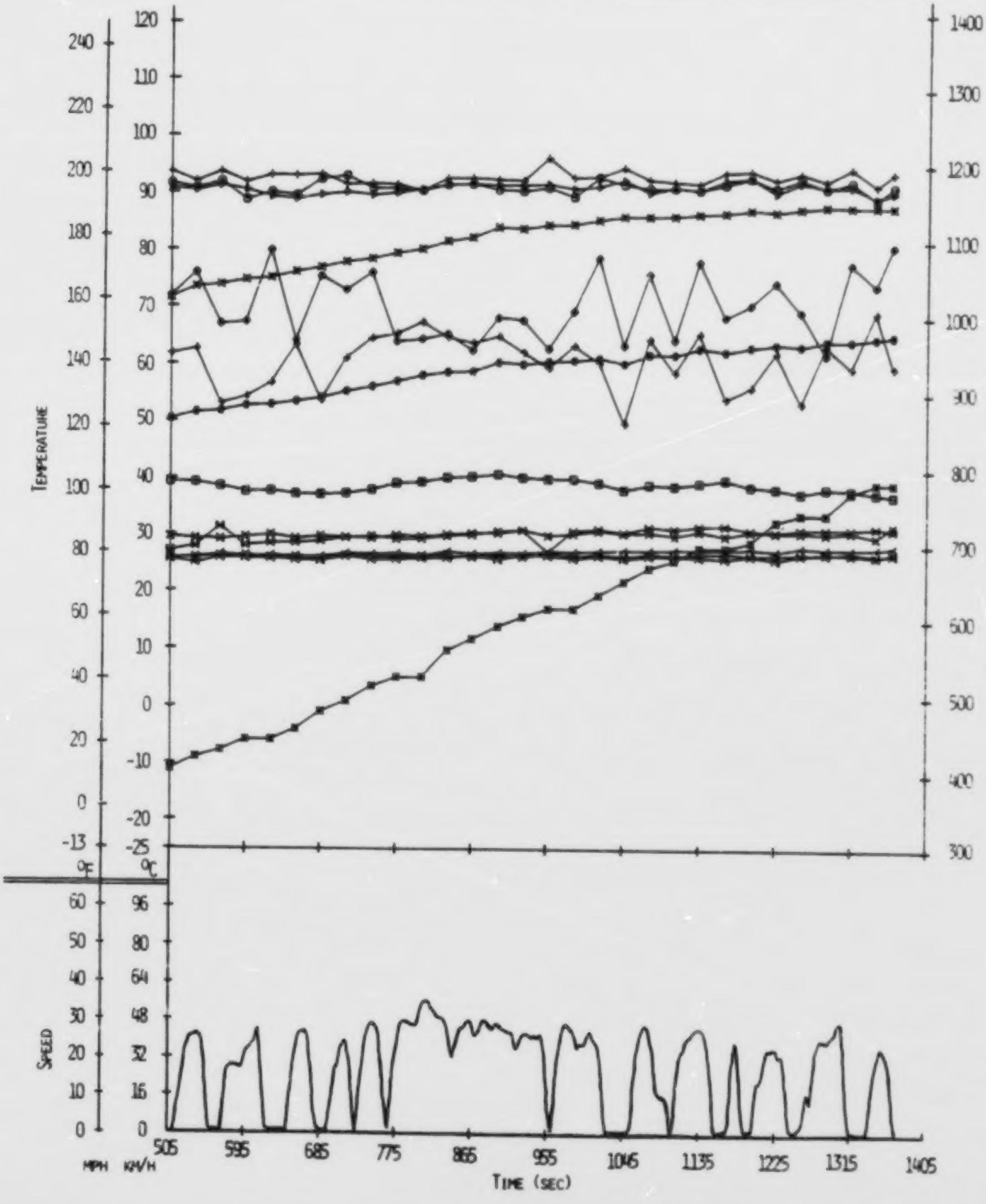
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
◠ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌧ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
ℕ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 68**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.2-2 TEST TEMPERATURE: 25 C

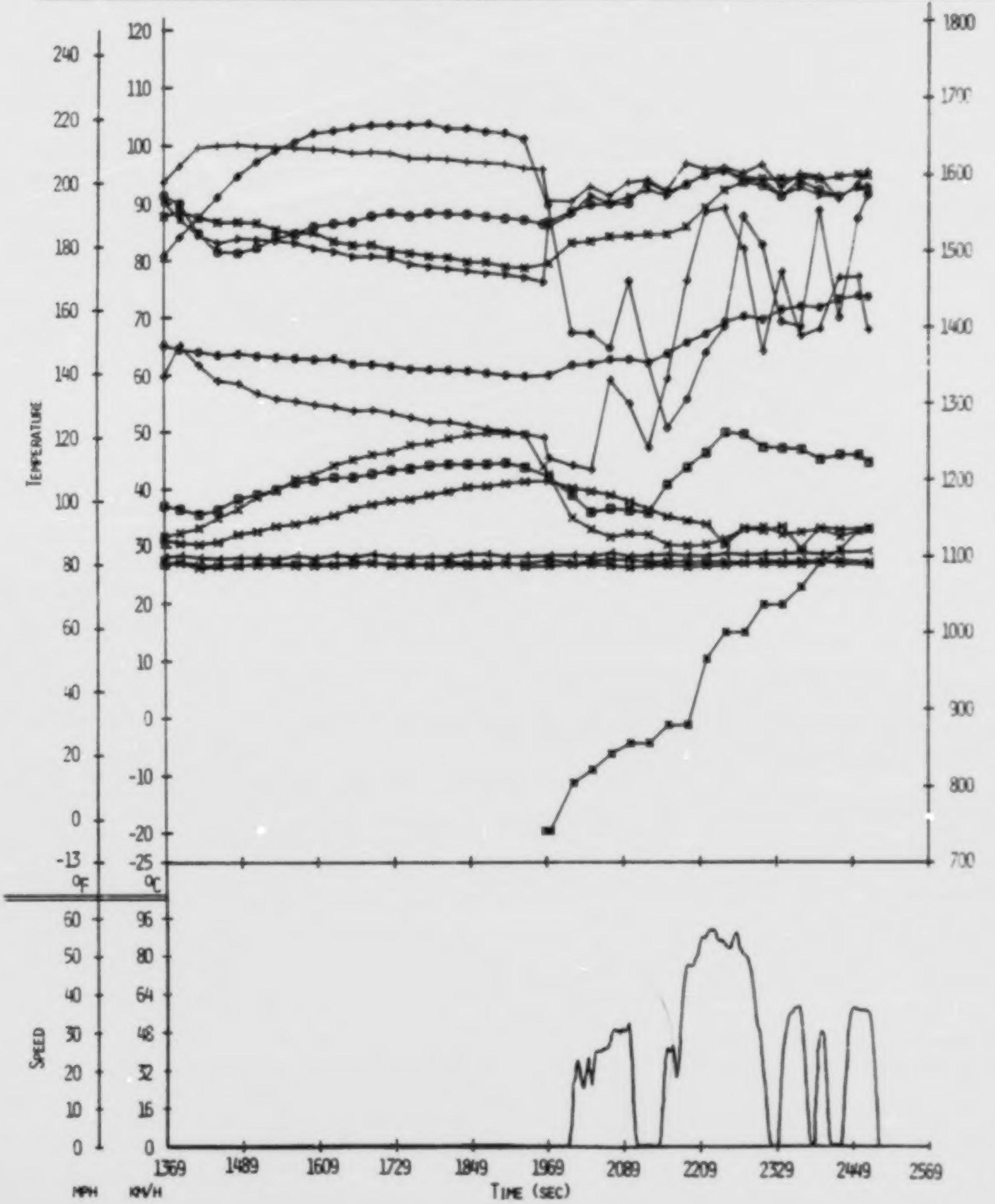
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
◔ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◑ — Int. Manifold Runner
▣ — Stove Output
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 69**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.2-2 TEST TEMPERATURE: 25 C

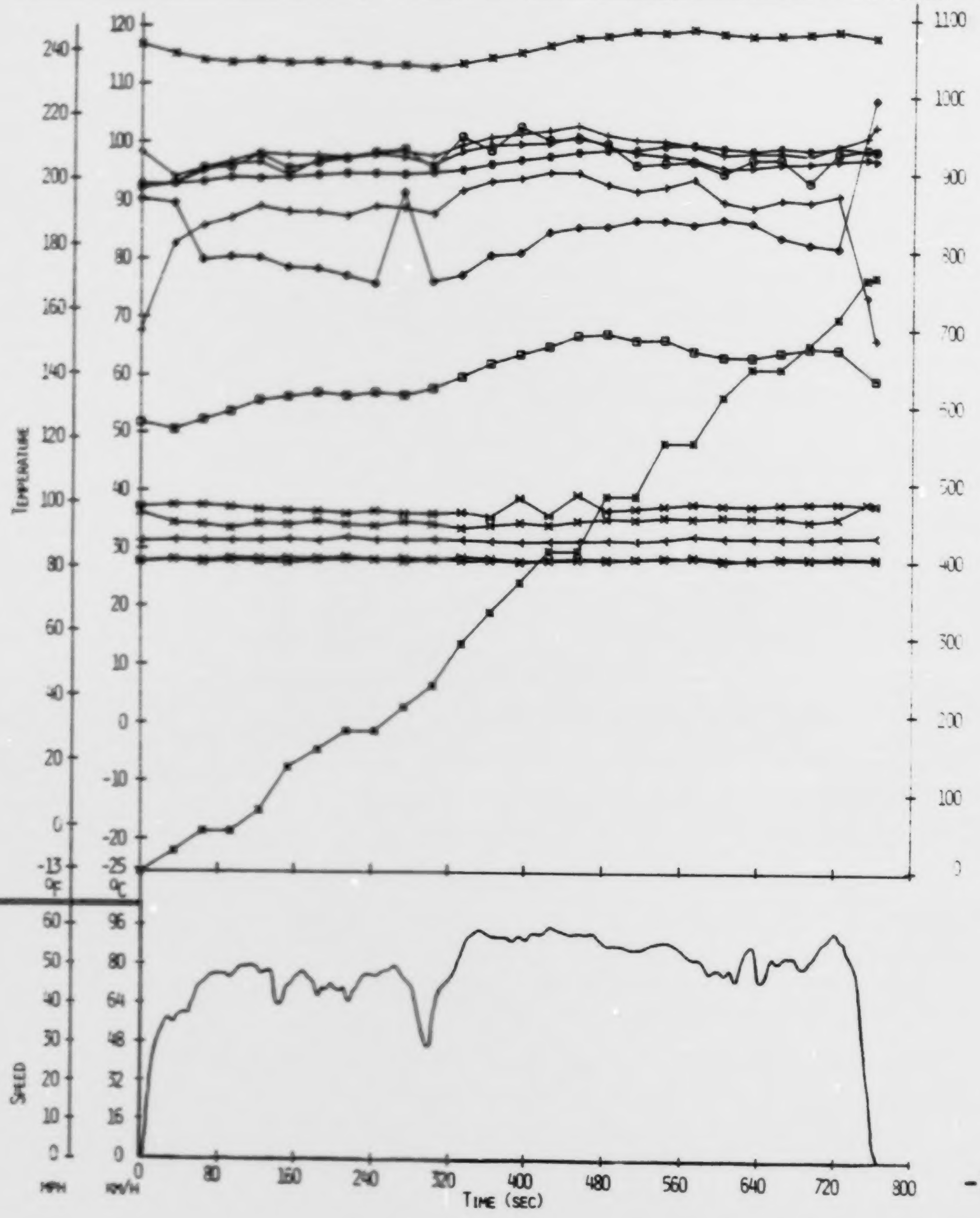
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **WITH AUTOMATIC IDLE SPEED**

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
● — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
□ — Stove Output
⌧ — Eng. Oil @ Dipstick
○ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⊢ — Fuel in - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 70**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.3-3 TEST TEMPERATURE: 0 C

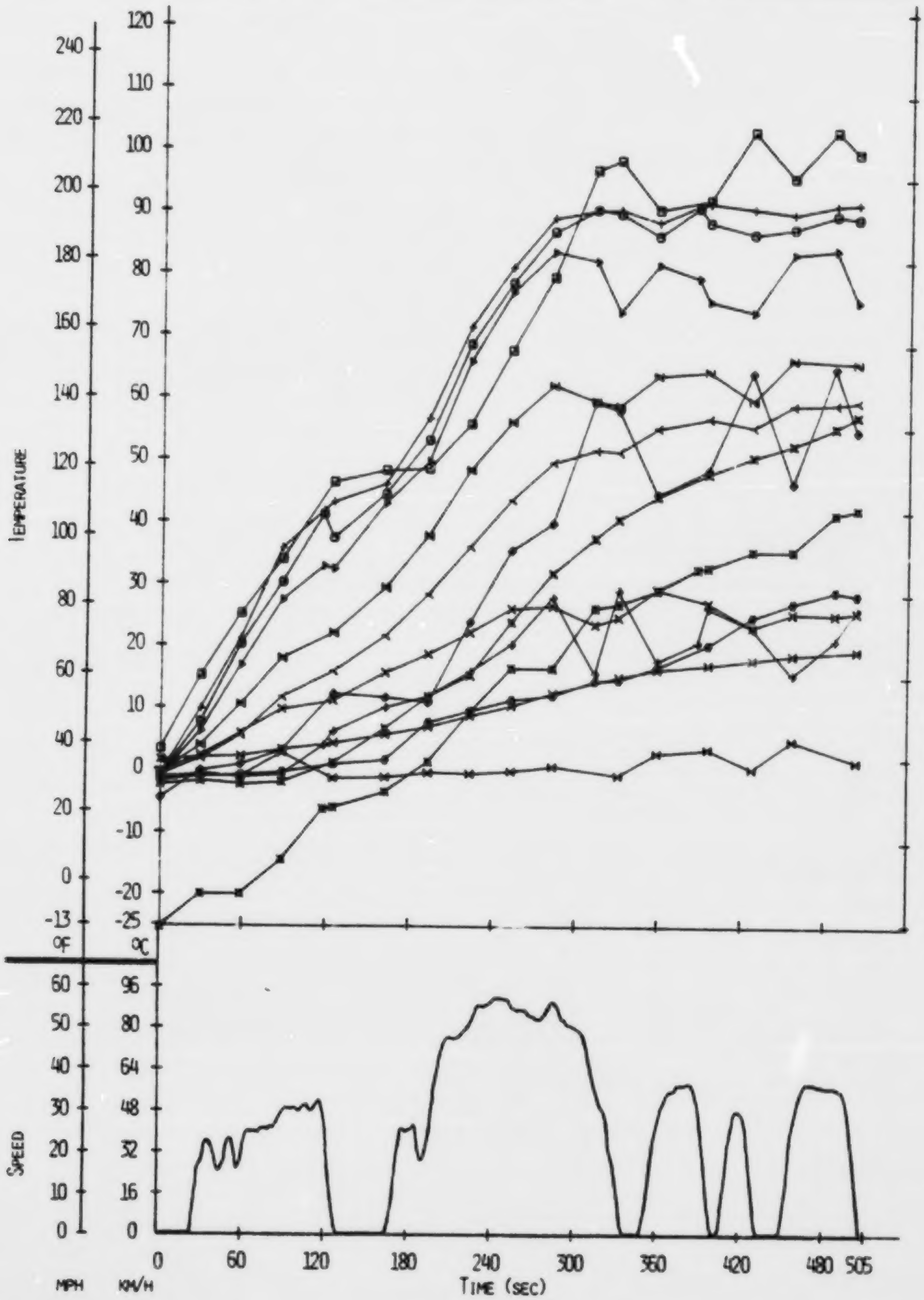
CITY CYCLE COLD TRANSIENT TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **BASE VEHICLE**

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
♦ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⌧ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



. TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 71**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.3-3 TEST TEMPERATURE: 0 C

CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: **BASE VEHICLE**

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hos
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◑ — Int. Manifold Runner
⊟ — Stove Output
ꟸ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
Ν — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
* — Fuel Consumed (Grams)

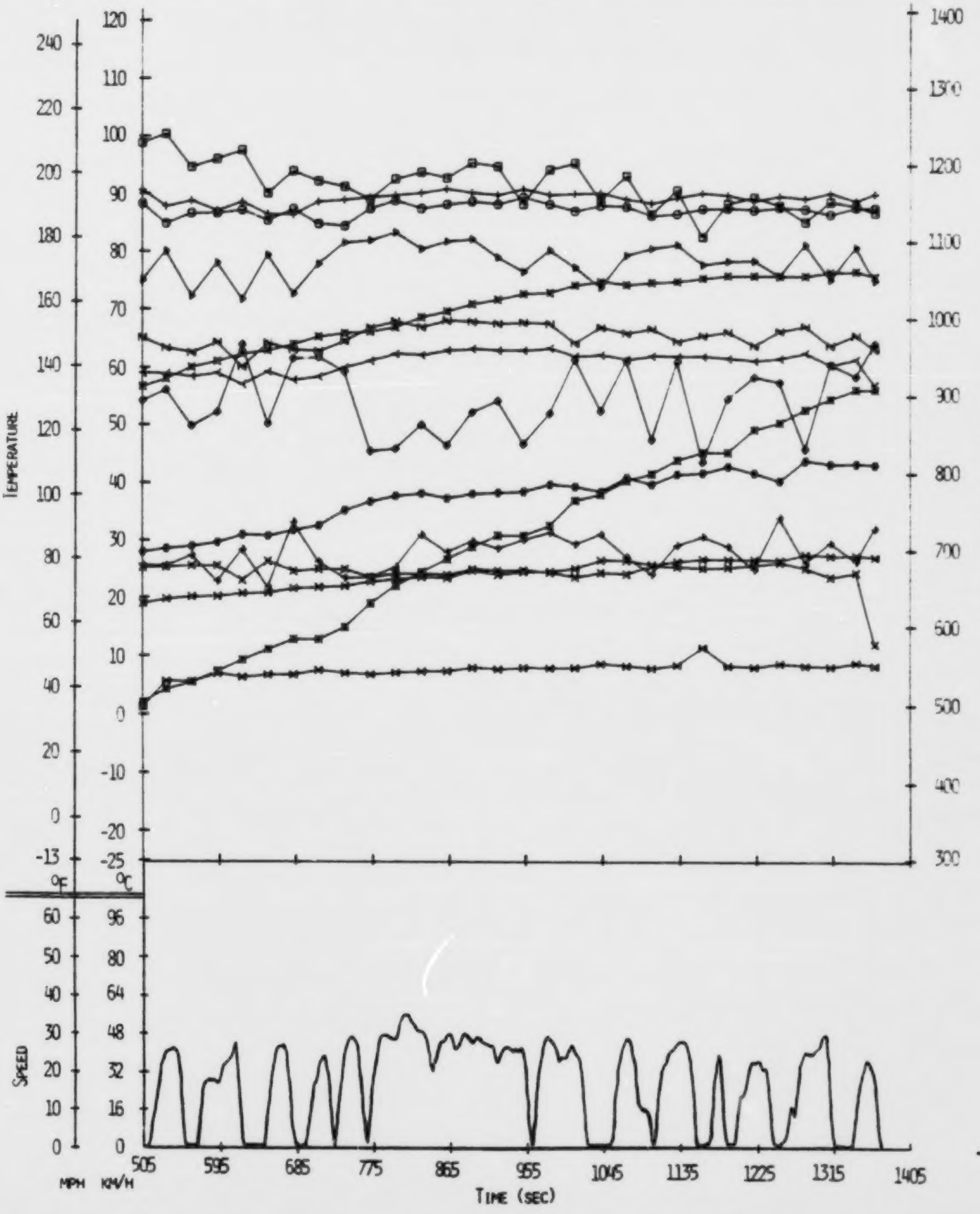


Figure 72

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.3-3 TEST TEMPERATURE: 0 C

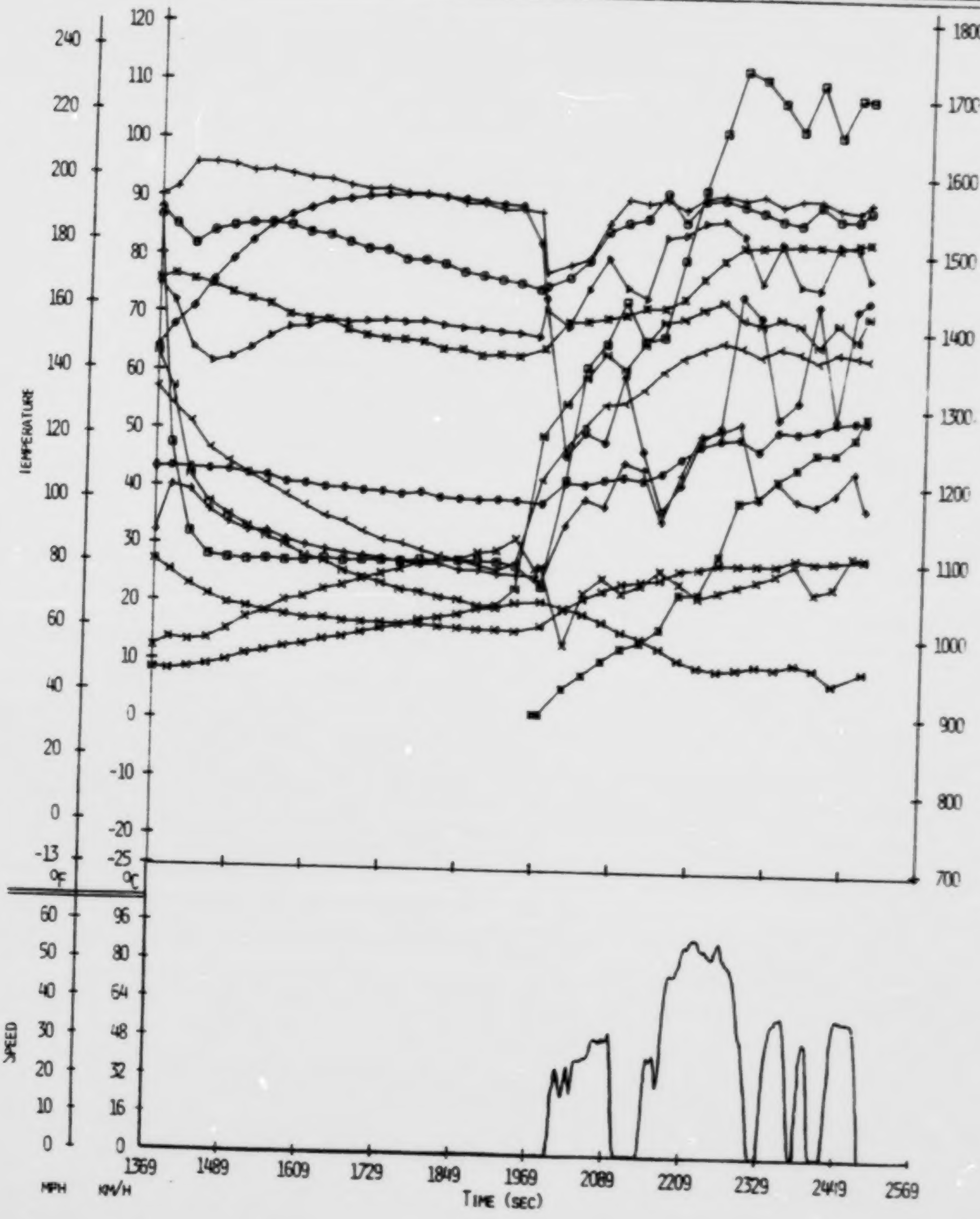
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
Ⓖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
₪ — Heater Duct - Right
⋈ — In Car Temp.
⧓ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure** 73

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.3-3 TEST TEMPERATURE: 0 C

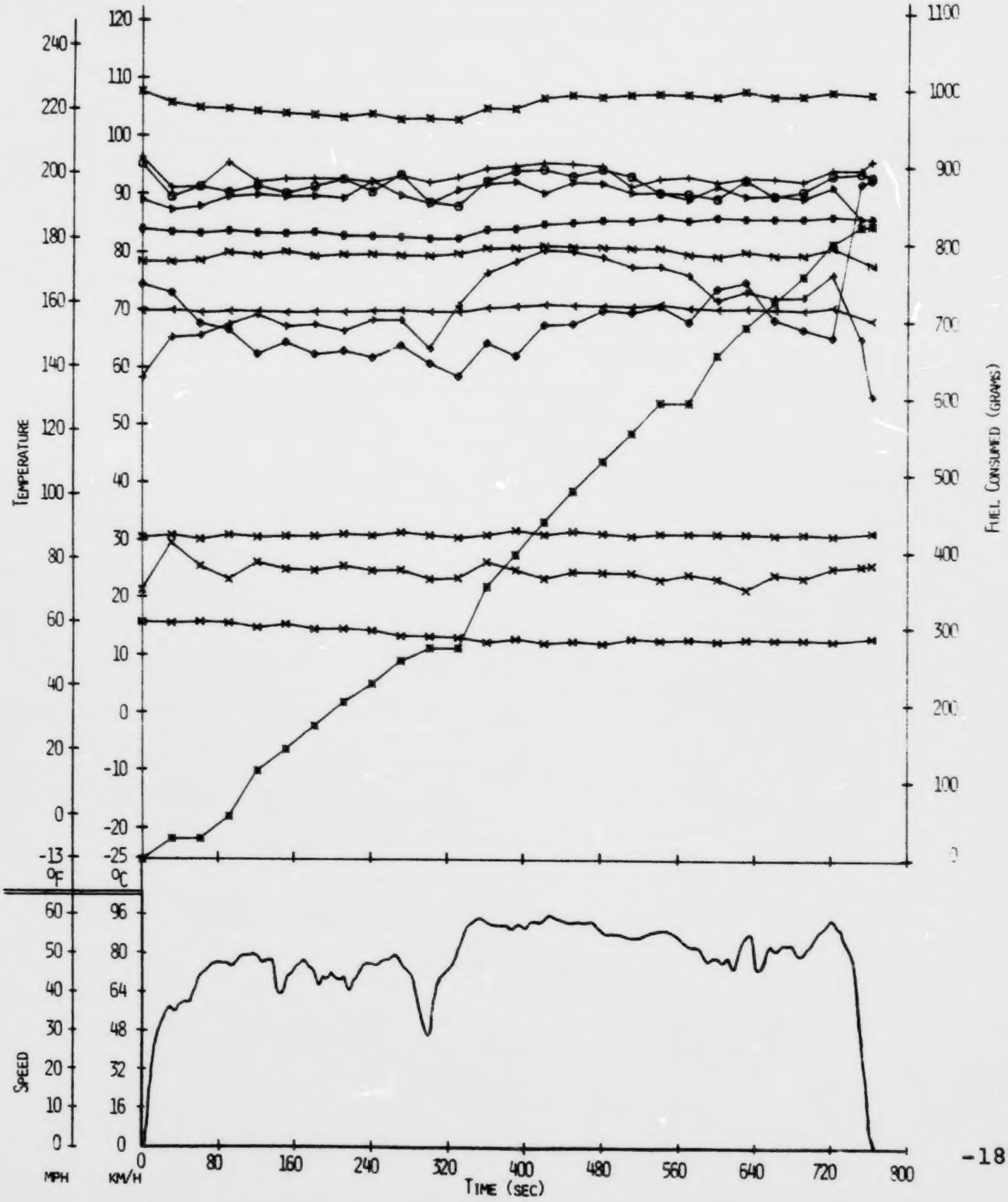
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 74**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.3-1 TEST TEMPERATURE: 0 C

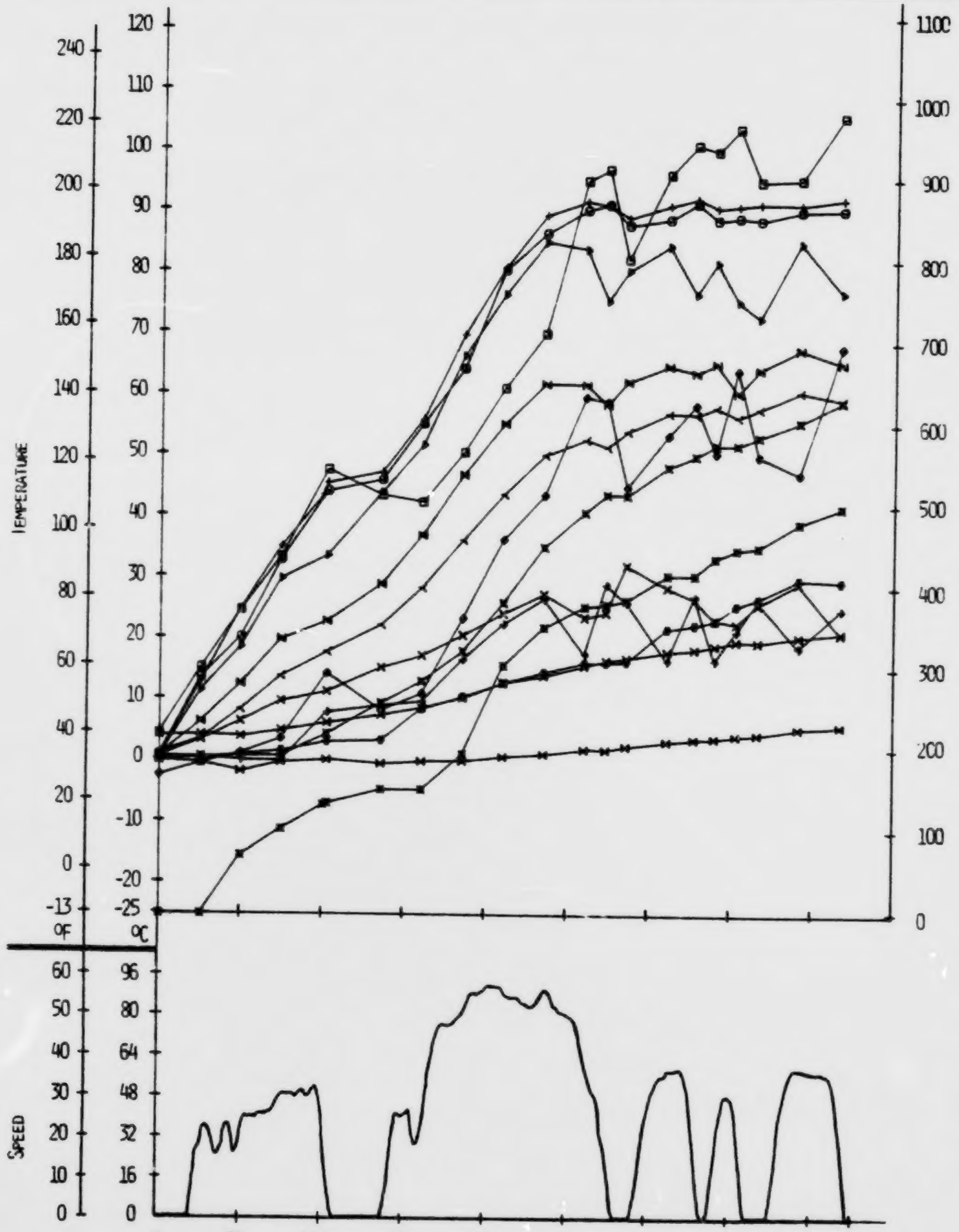
CITY CYCLE COLD TRANSIENT TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine, 1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ꟿ — Heater Duct - Right
⋈ — In Car Temp.
⧓ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 75**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.3-1 TEST TEMPERATURE: 0 C

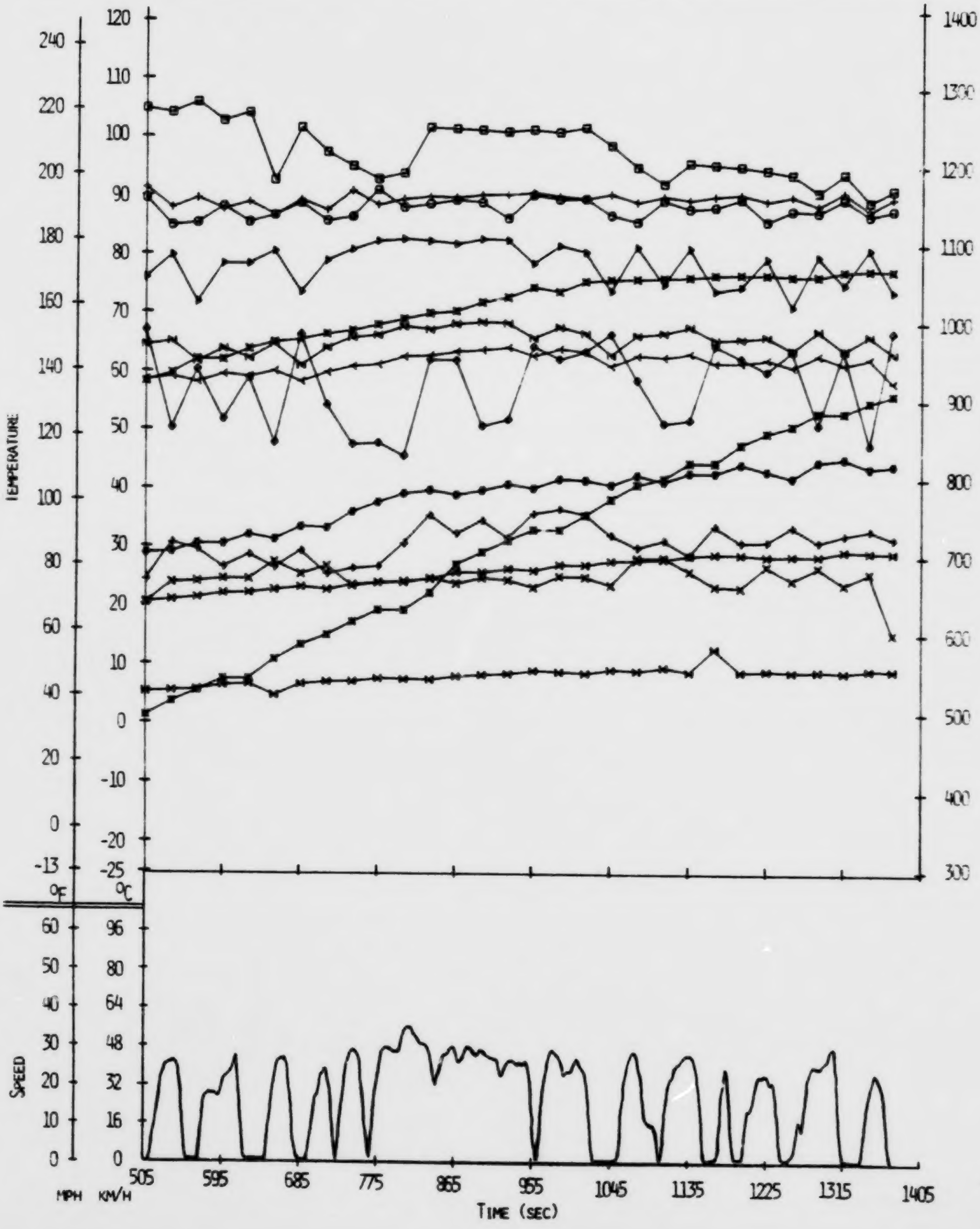
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
- + — Coolant - Thermostat
- ⊕ — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◈ — Int. Manifold Runner
- ⊟ — Stove Output
- ⌑ — Eng. Oil @ Dipstick
- ✤ — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ℕ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel in - Carb. Bowl
- ✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 76**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.3-1 TEST TEMPERATURE: 0 C

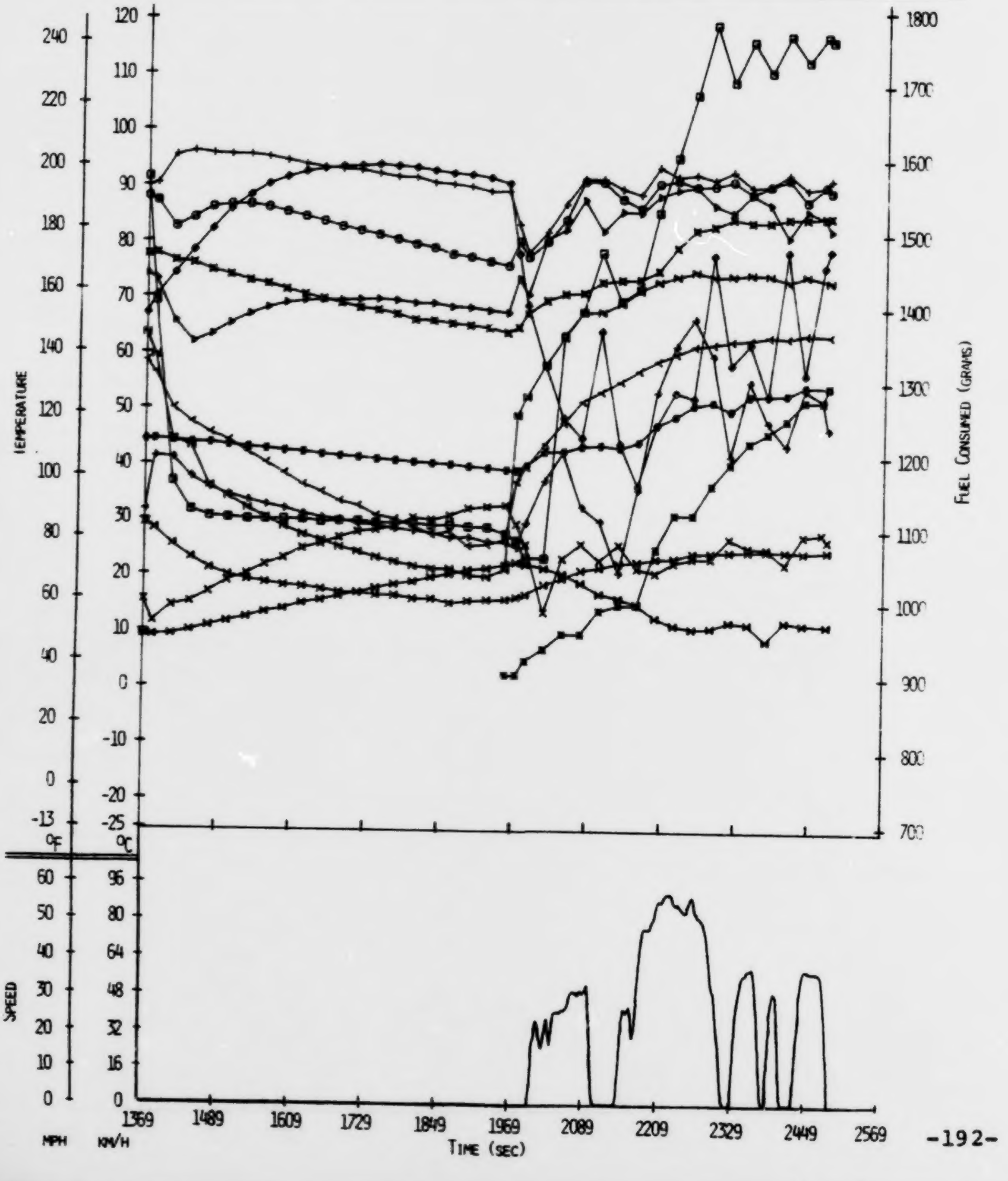
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
- + — Coolant - Thermostat
- ✦ — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⊟ — Stove Output
- ⌑ — Eng. Oil @ Dipstick
- ✱ — Trans. Oil @ Dipstick
- < — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel in - Carb. Bowl
- * — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 77**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.3-1 TEST TEMPERATURE: 0 C

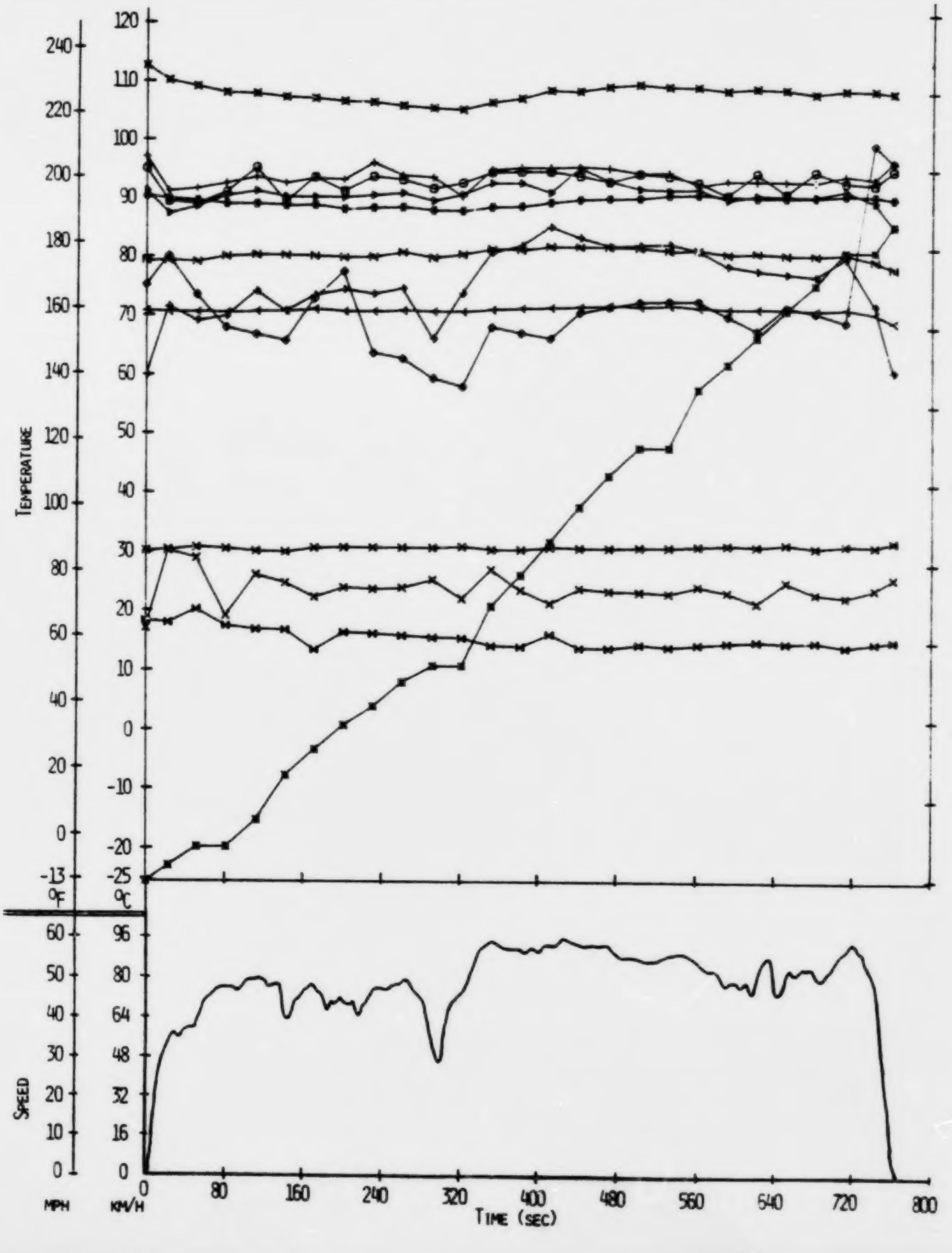
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 78

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.4.1 TEST TEMPERATURE: -20 C

CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

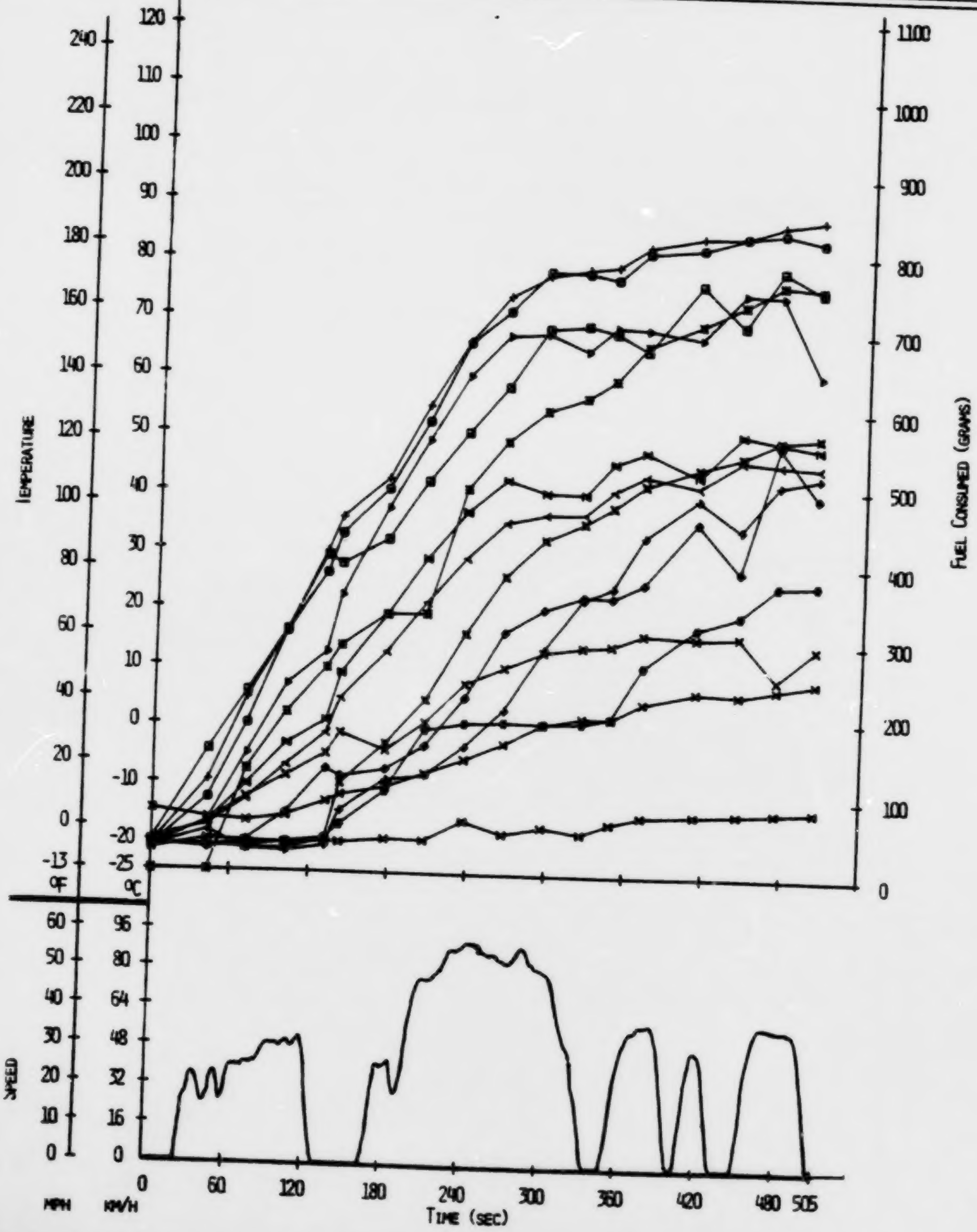
HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine, 1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)

+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
⊳ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⧓ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 79

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.4.1 TEST TEMPERATURE: -20 C

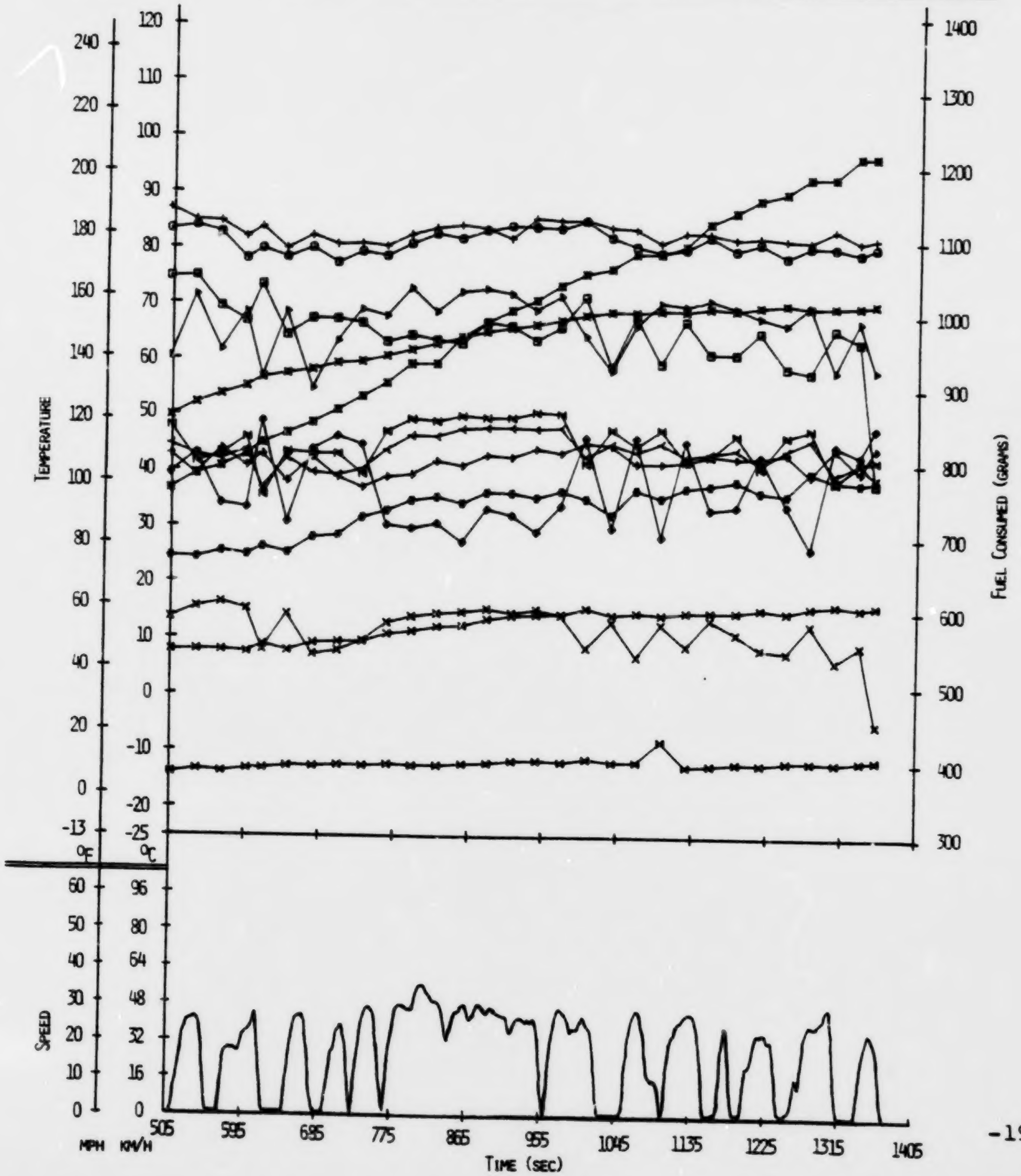
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
➔ — Coolant - Lower Rad. Hose
ϴ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌧ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 80

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED

TEST NO: 3.1.4.1

TEST TEMPERATURE: -20 C

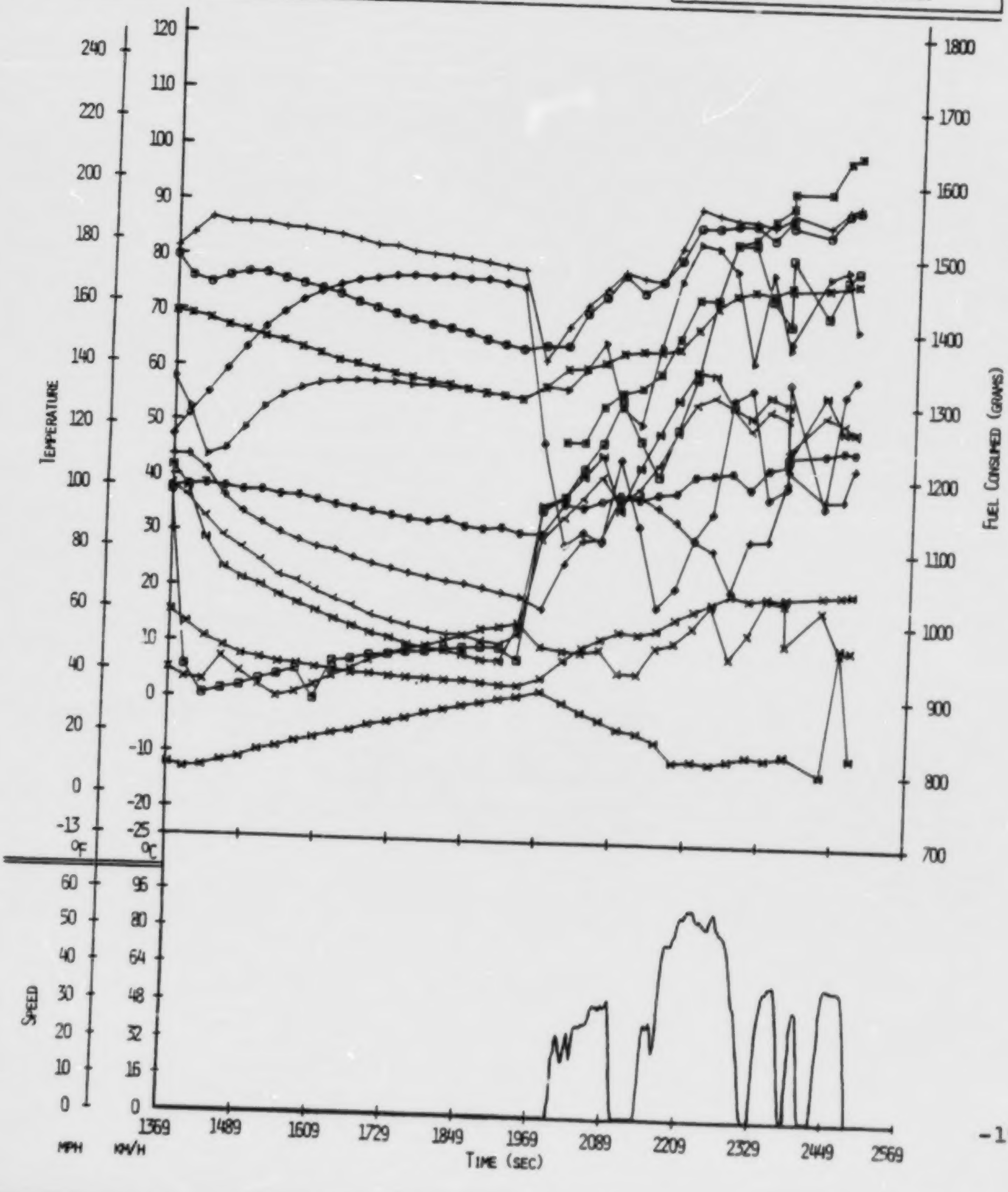
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine, 1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⌘ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
⋌ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 81

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.1.4.1 TEST TEMPERATURE: -20 C

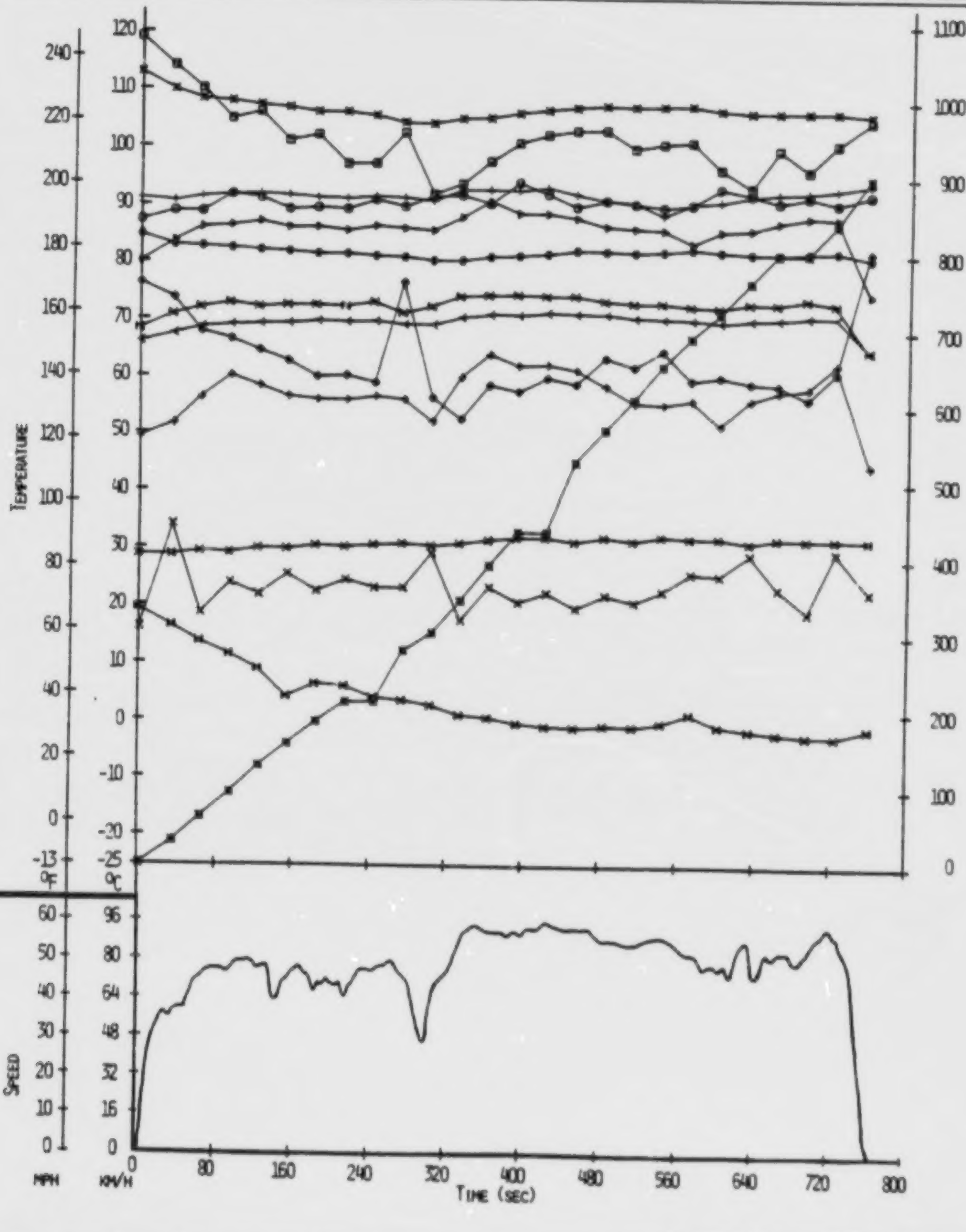
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: BASE VEHICLE

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊟ — Stove Output
⊠ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 82

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED   TEST NO: 3.2.4-2   TEST TEMPERATURE: -20 C

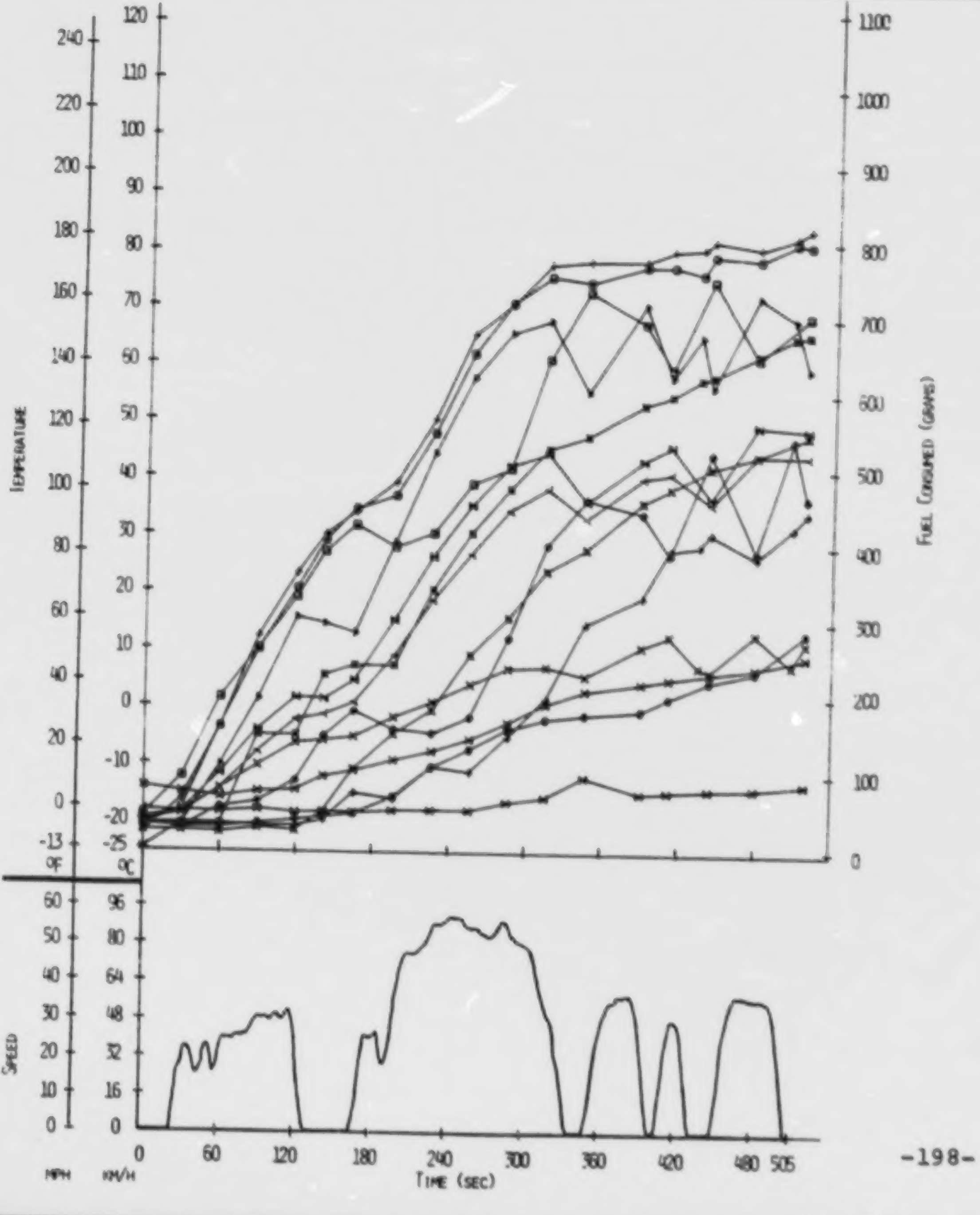
CITY CYCLE COLD TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
ɸ — Coolant - Lower Rad. Hose
∩ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⌘ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 83

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED   TEST NO: 3.2.4-2   TEST TEMPERATURE: -20 C

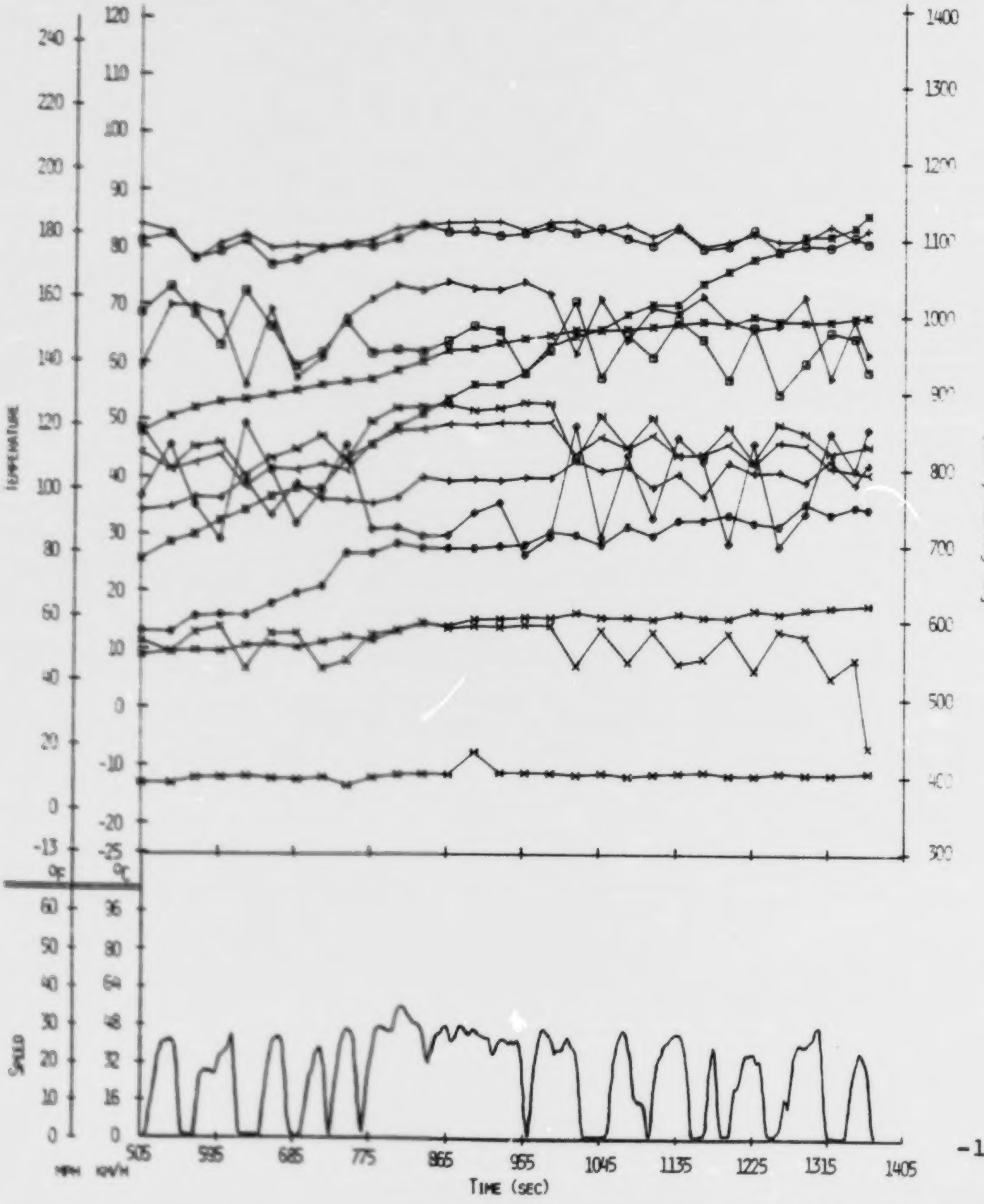
CITY CYCLE COLD STABILIZED
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
● — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◔ — Int. Manifold Runner
⊡ — Stove Output
Ħ — Eng. Oil @ Dipstick
⚙ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 84**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.4-2 TEST TEMPERATURE: -20 C

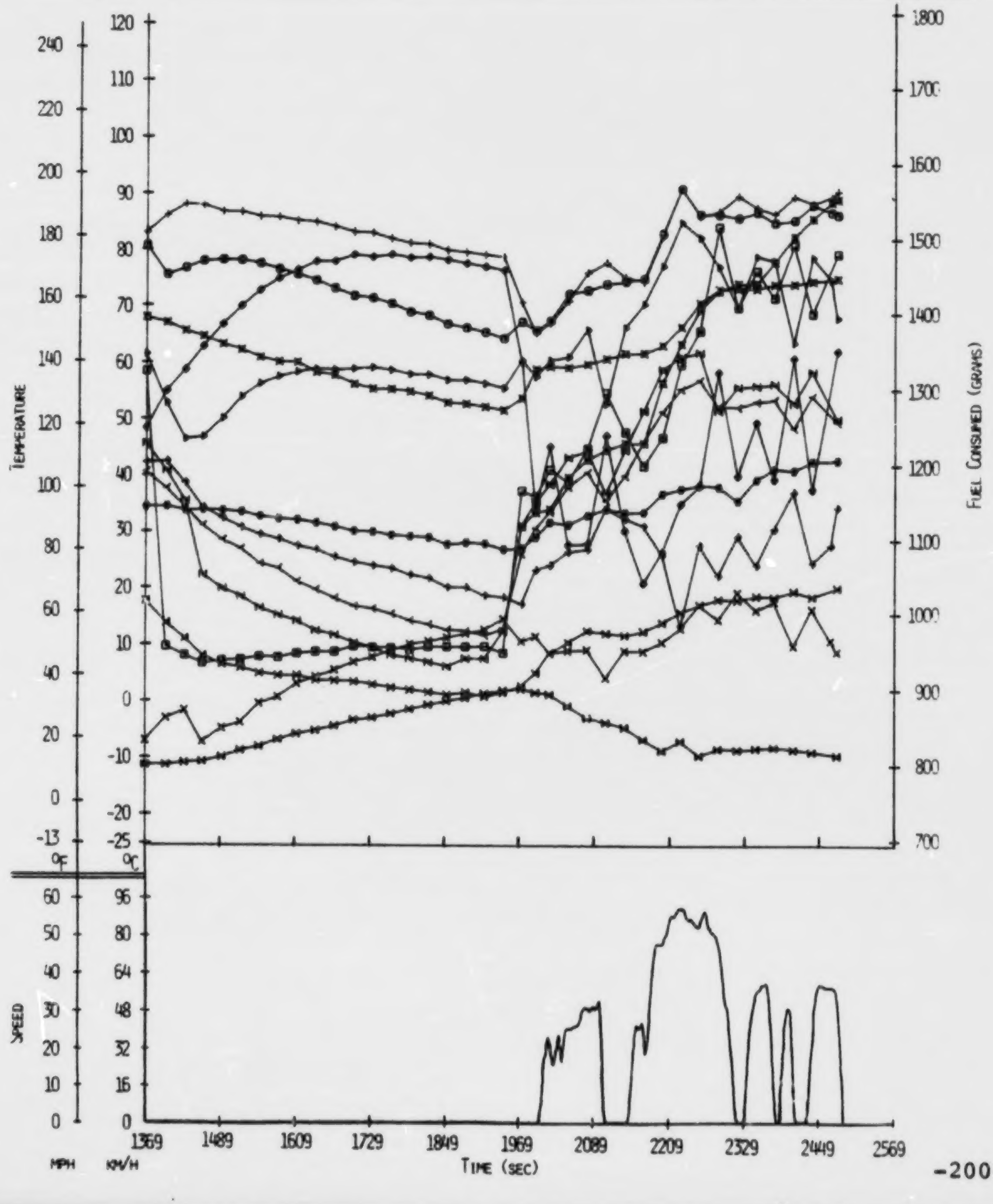
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊡ — Stove Output
⌘ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
* — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 85**

VEHICLE NUMBER: 3 AUTOMATIC IDLE SPEED TEST NO: 3.2.4-2 TEST TEMPERATURE: -20 C

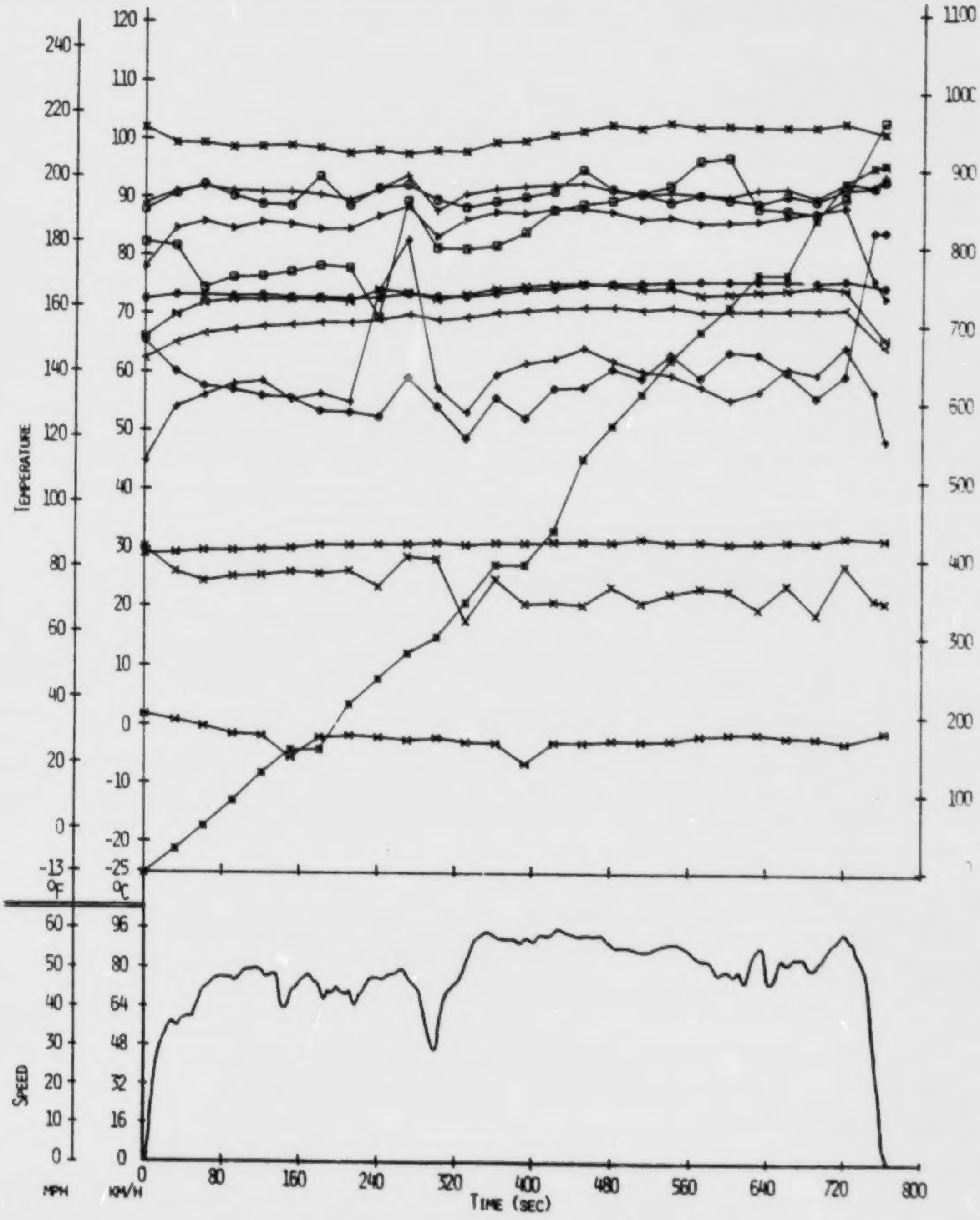
HIGHWAY CYCLE
TEMPERATURE AND FUEL CONS. TRACE

HARDWARE CONFIGURATION: WITH AUTOMATIC IDLE SPEED

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 3)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
⊙ — Int. Manifold Runner
⊡ — Stove Output
⌘ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
< — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel in - Carb. Bowl
✱ — Fuel Consumed (Grams)



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 86**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.2-2 TEST TEMPERATURE: 25 C

CITY CYCLE COLD TRANSIENT TEMPERATURE TRACE

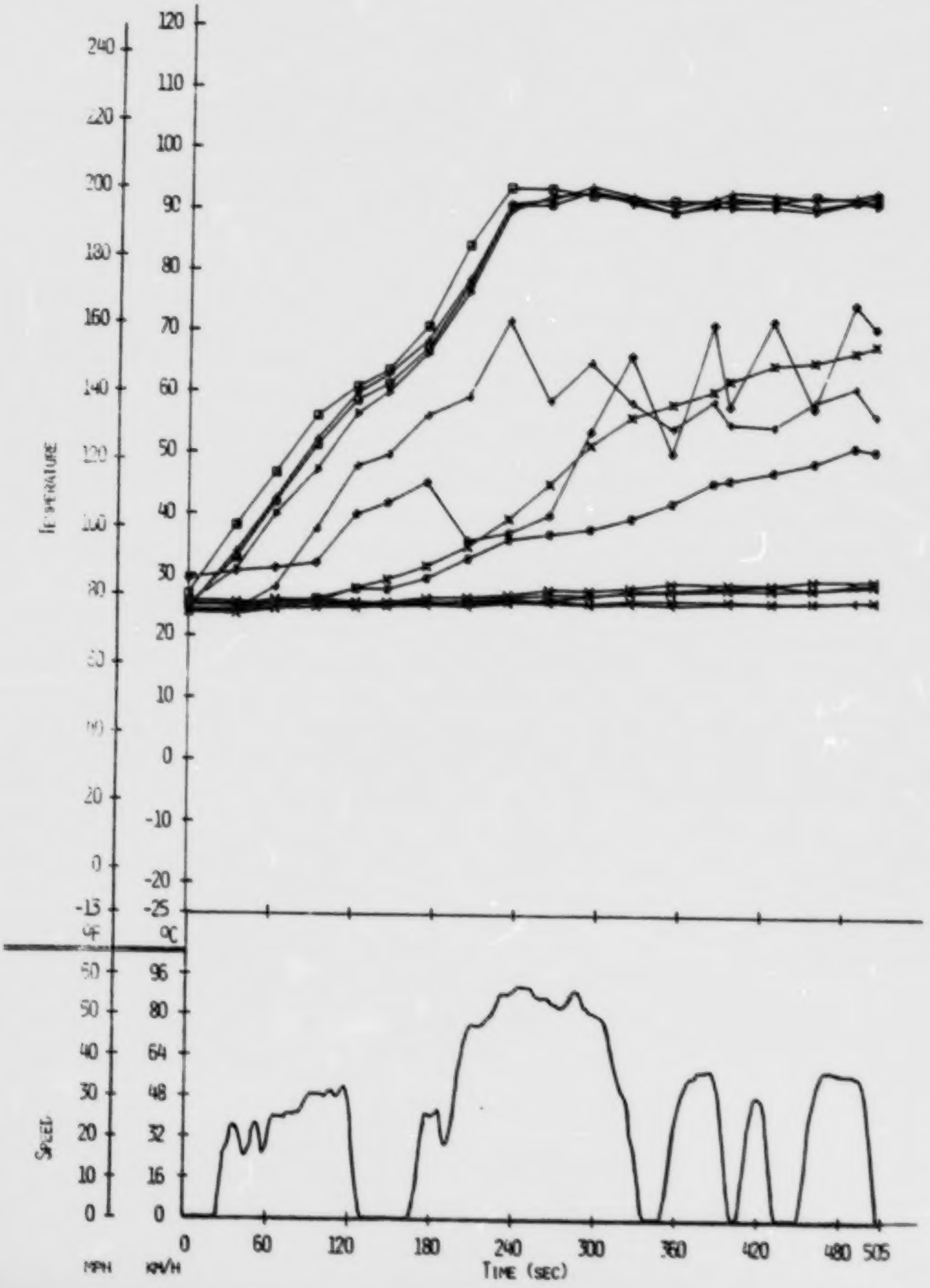
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
◯ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊠ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
▣ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 87

VEHICLE NO: 9 PROPANE TEST NO: 9.1.2-2 TEST TEMPERATURE: 25 C

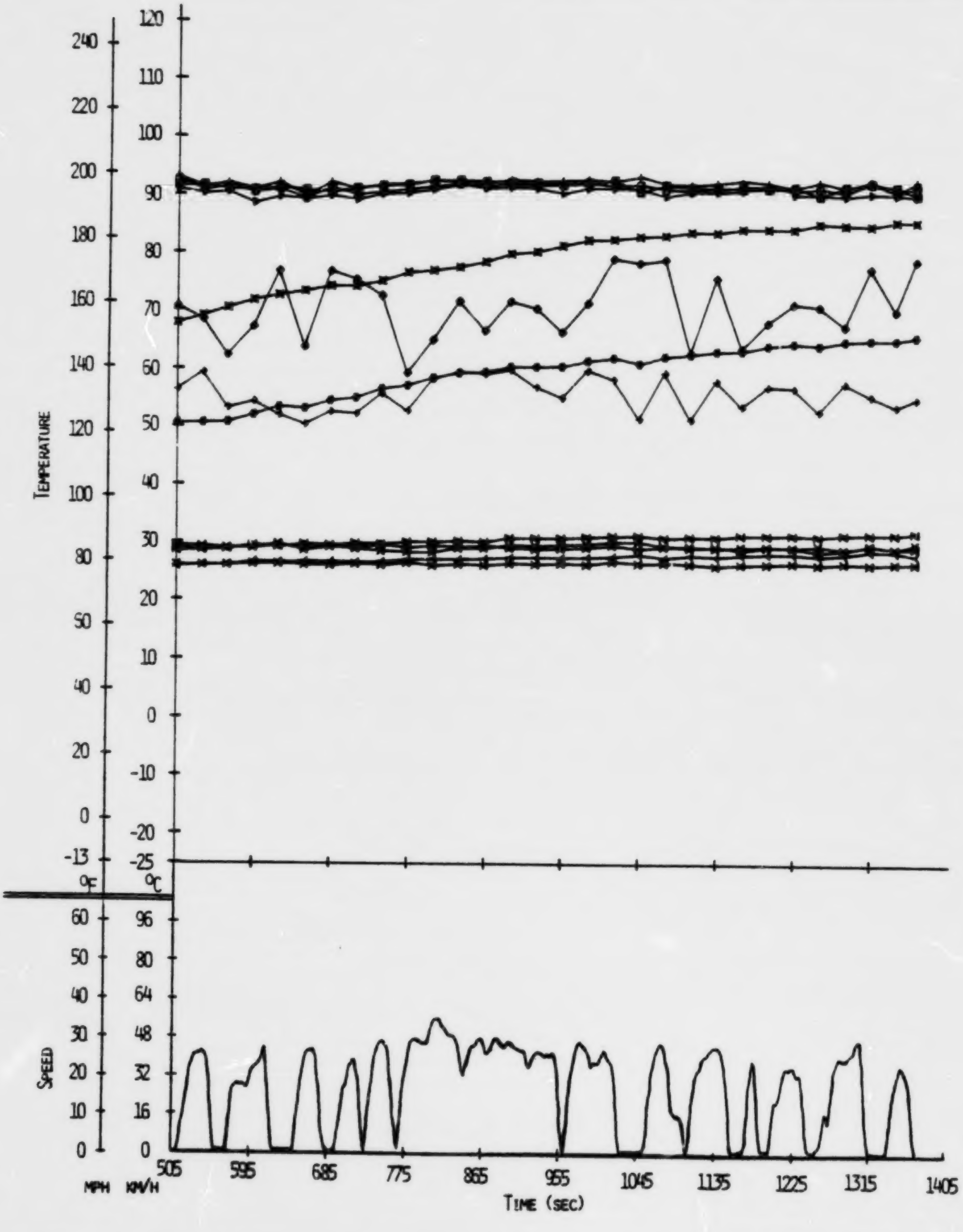
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 88

VEHICLE No: 9 PROPANE

TEST No: 9.1.2-2

TEST TEMPERATURE: 25 C

CITY CYCLE SOAK & HOT TRANSIENT TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
Ν — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out

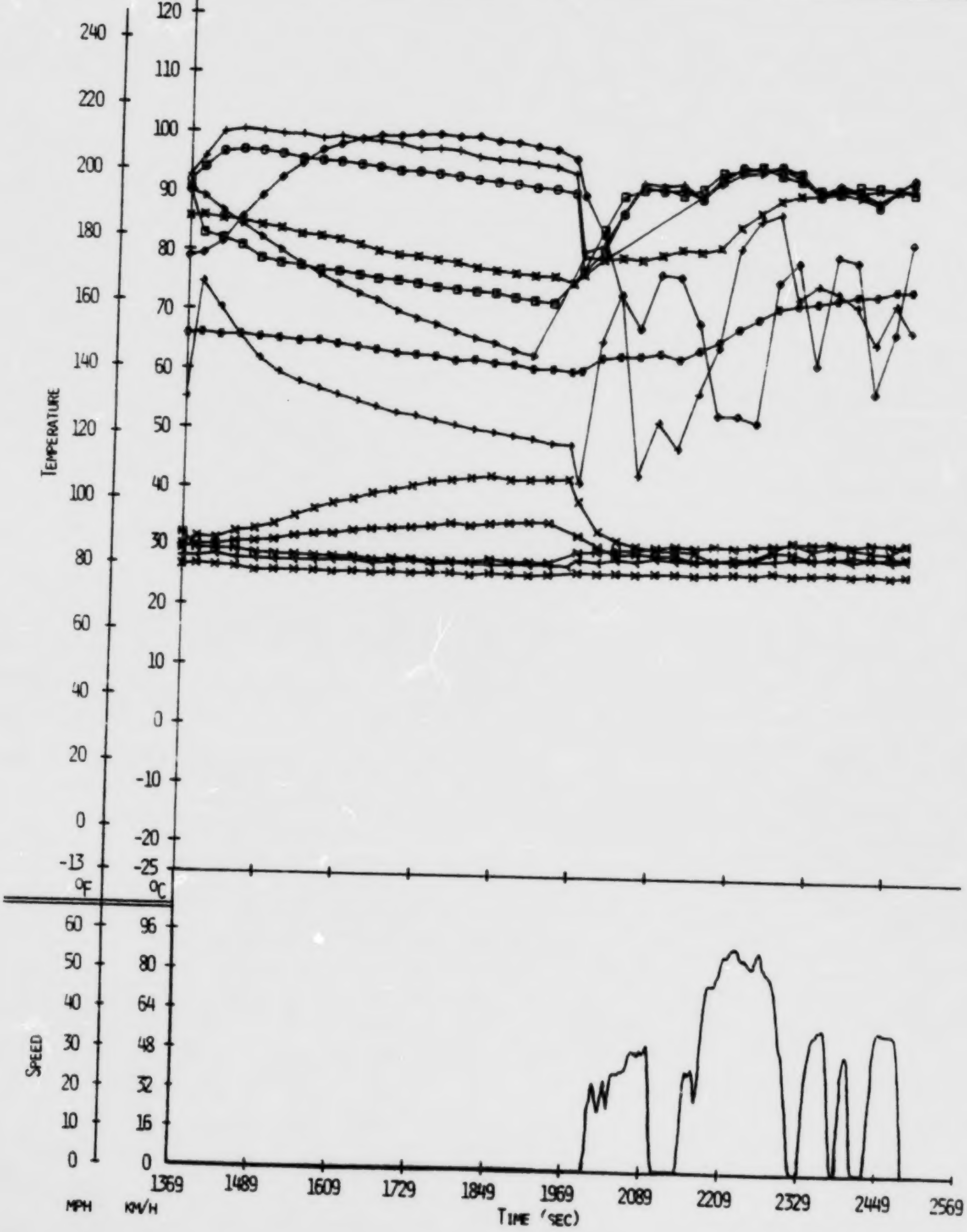


Figure 89

VEHICLE NO: 9 PROPANE TEST NO: 9.1.2-2 TEST TEMPERATURE: 25 C

HIGHWAY CYCLE
TEMPERATURE TRACE

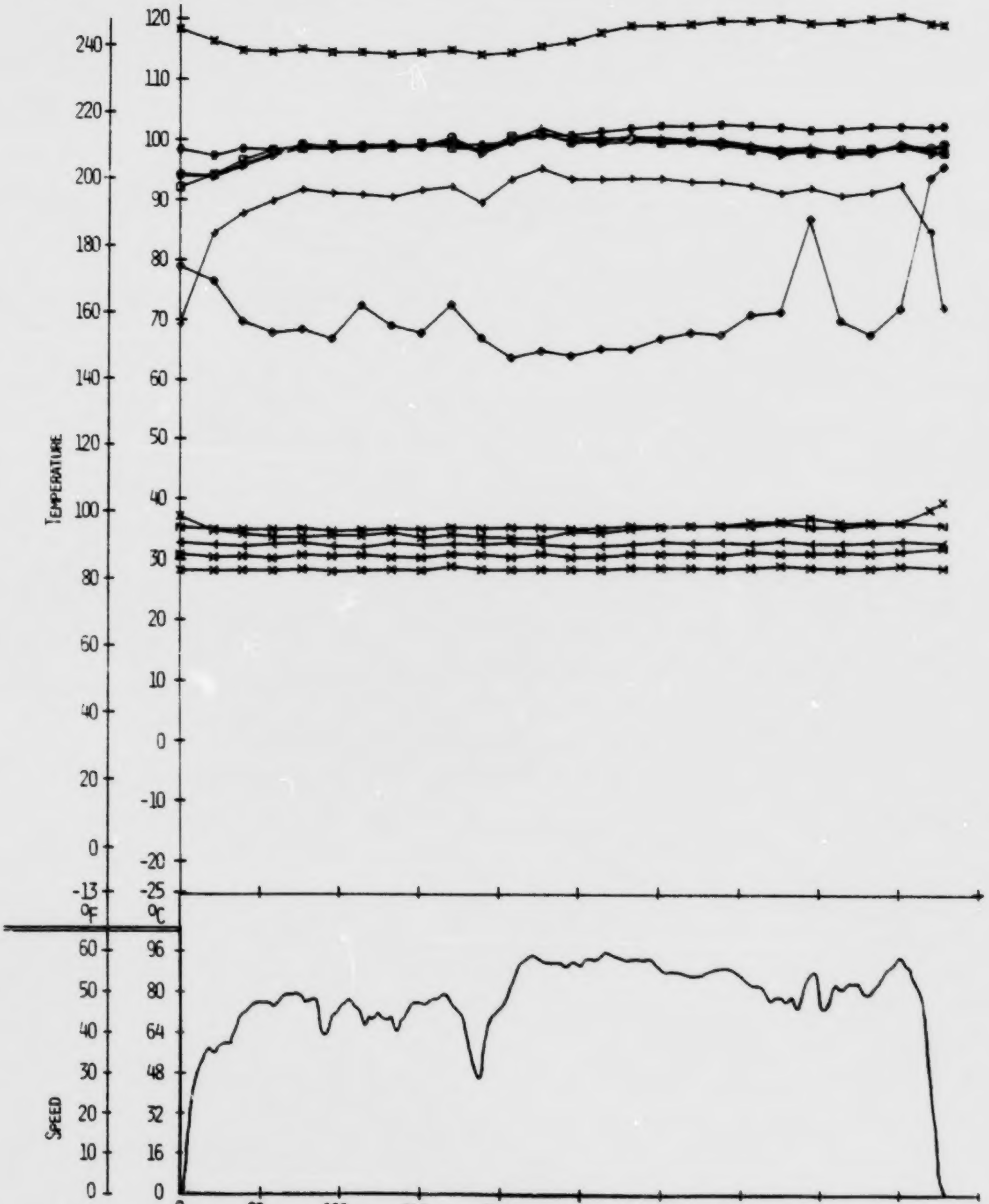
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

- + — Coolant - Thermostat
- ⇾ — Coolant - Lower Rad. Hose
- ○ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⌑ — Eng. Oil @ Dipstick
- ✿ — Trans. Oil @ Dipstick
- ⤙ — Heater Duct - Left
- ⅃ — Heater Duct - Right
- ⋈ — In Car Temp.
- ⋈ — Fuel - Vapourizer In
- ◫ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 90

VEHICLE NO: 9 PROPANE

TEST NO: 9.2.2-1

TEST TEMPERATURE: 25 C

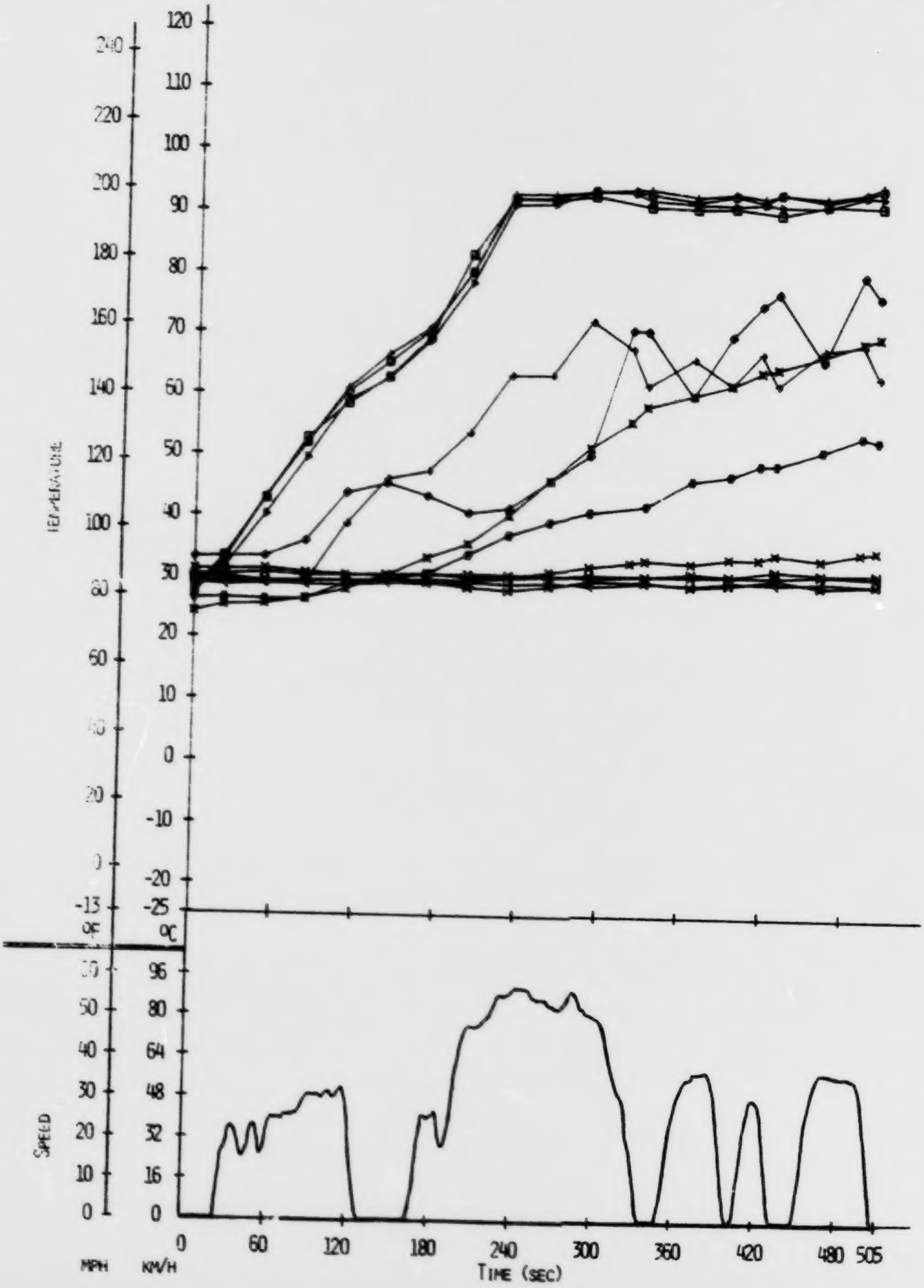
CITY CYCLE COLD TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 91**

VEHICLE NO: 9 PROPANE TEST NO: 9.2.2-1 TEST TEMPERATURE: 25 C

CITY CYCLE COLD STABILIZED TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊠ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer [illegible]
⊟ — Coolant - Vapourizer Out

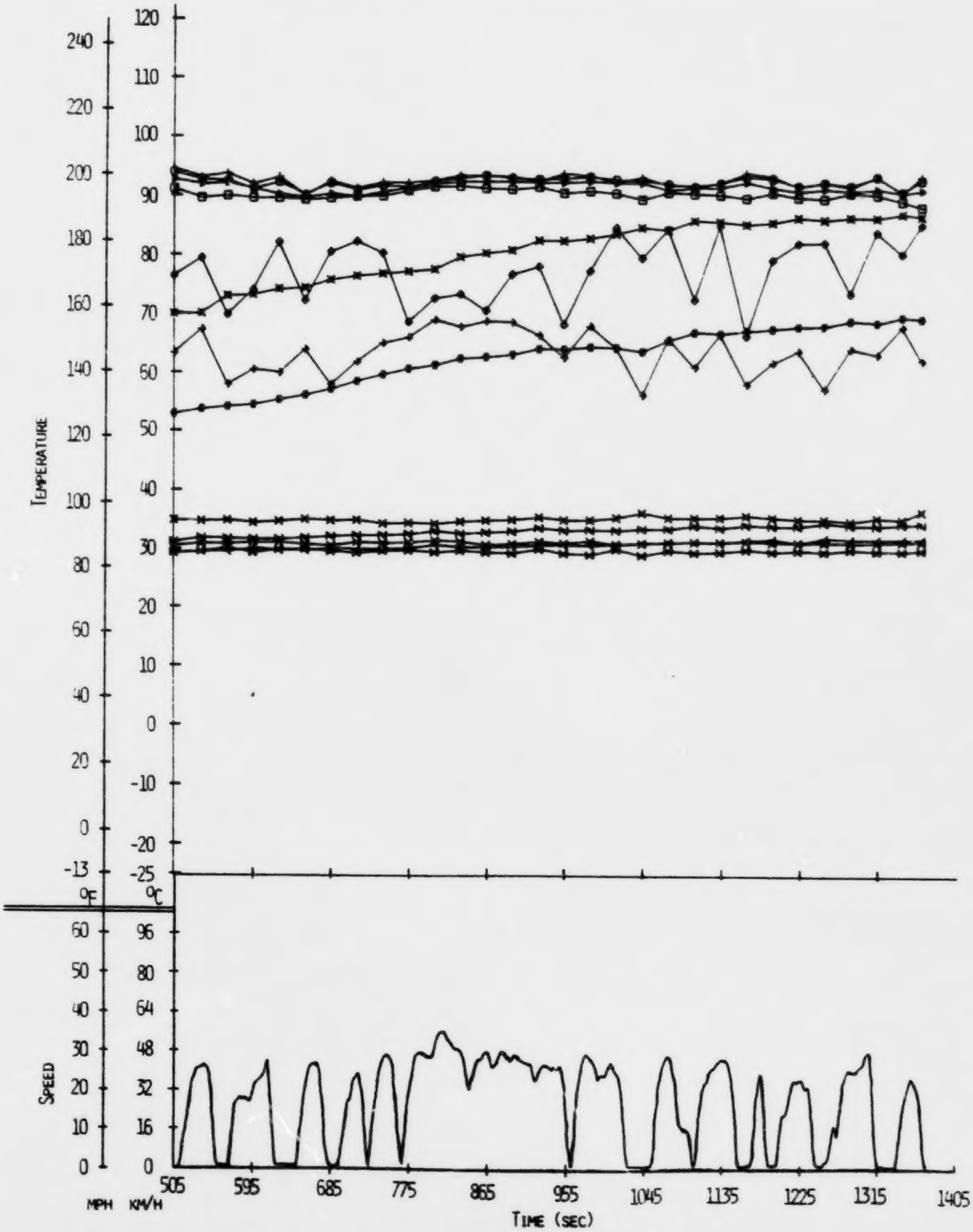


Figure 92

VEHICLE NO: 9 PROPANE   TEST NO: 9.2.2-1   TEST TEMPERATURE: 25 C

CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
- + — Coolant - Thermostat
- ⊕ — Coolant - Lower Rad. Hose
- ⊖ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⌑ — Eng. Oil @ Dipstick
- ✲ — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ℕ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel - Vapourizer In
- ⊡ — Coolant - Vapourizer Out

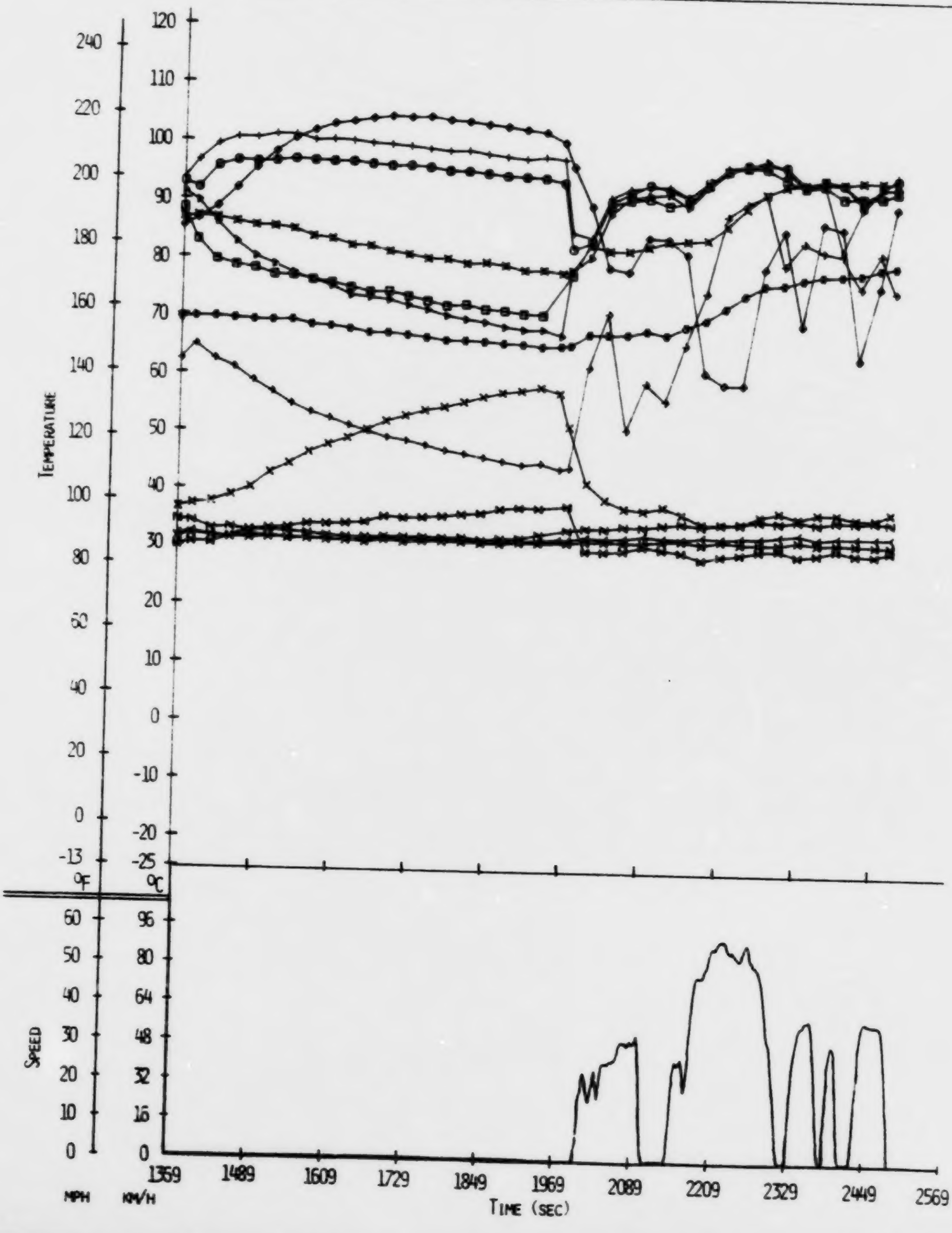


Figure 93

VEHICLE NO: 9 PROPANE
TEST NO: 9.2.2-1
TEST TEMPERATURE: 25 C

HIGHWAY CYCLE
TEMPERATURE TRACE

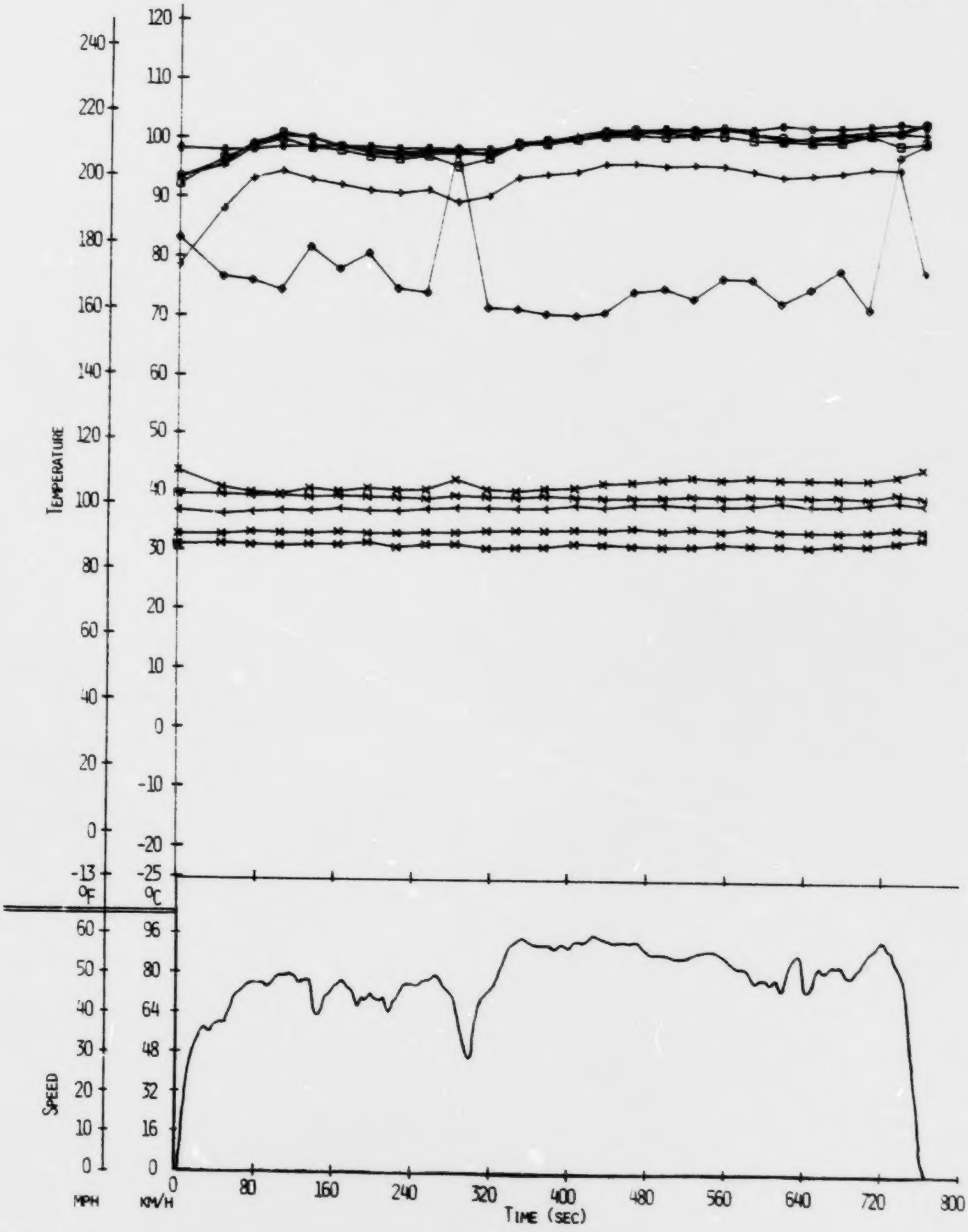
HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
⊗ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊐ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 94

VEHICLE NO: 9 PROPANE TEST NO: 9.1.3-1 TEST TEMPERATURE: 0 C

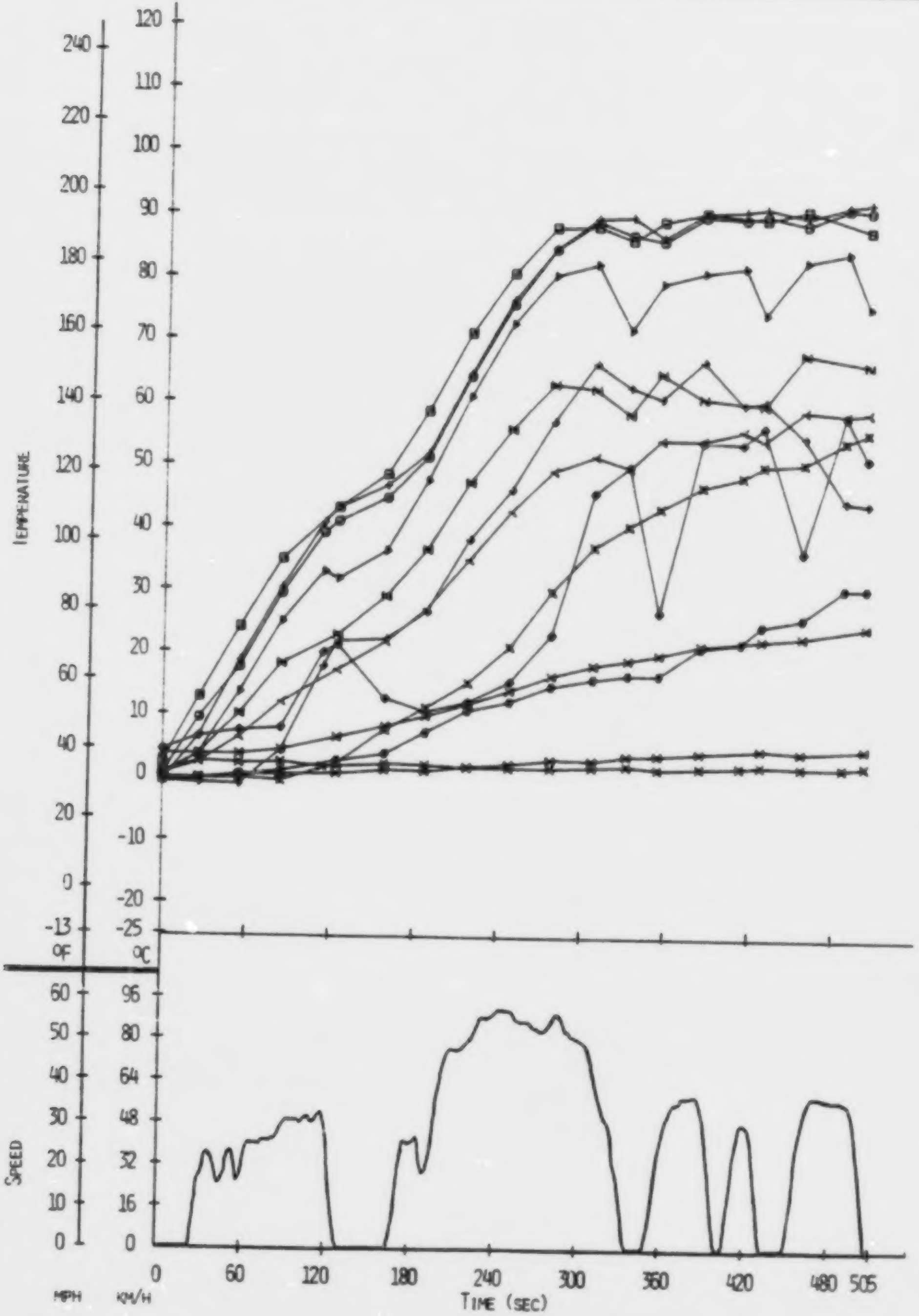
CITY CYCLE COLD TRANSIENT TEMPERATURE TRACE

HARDWARE CONFIGURATION: **A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS**

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× -- Carb. Air In
ç — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N -- Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 95**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.3-1 TEST TEMPERATURE: 0 C

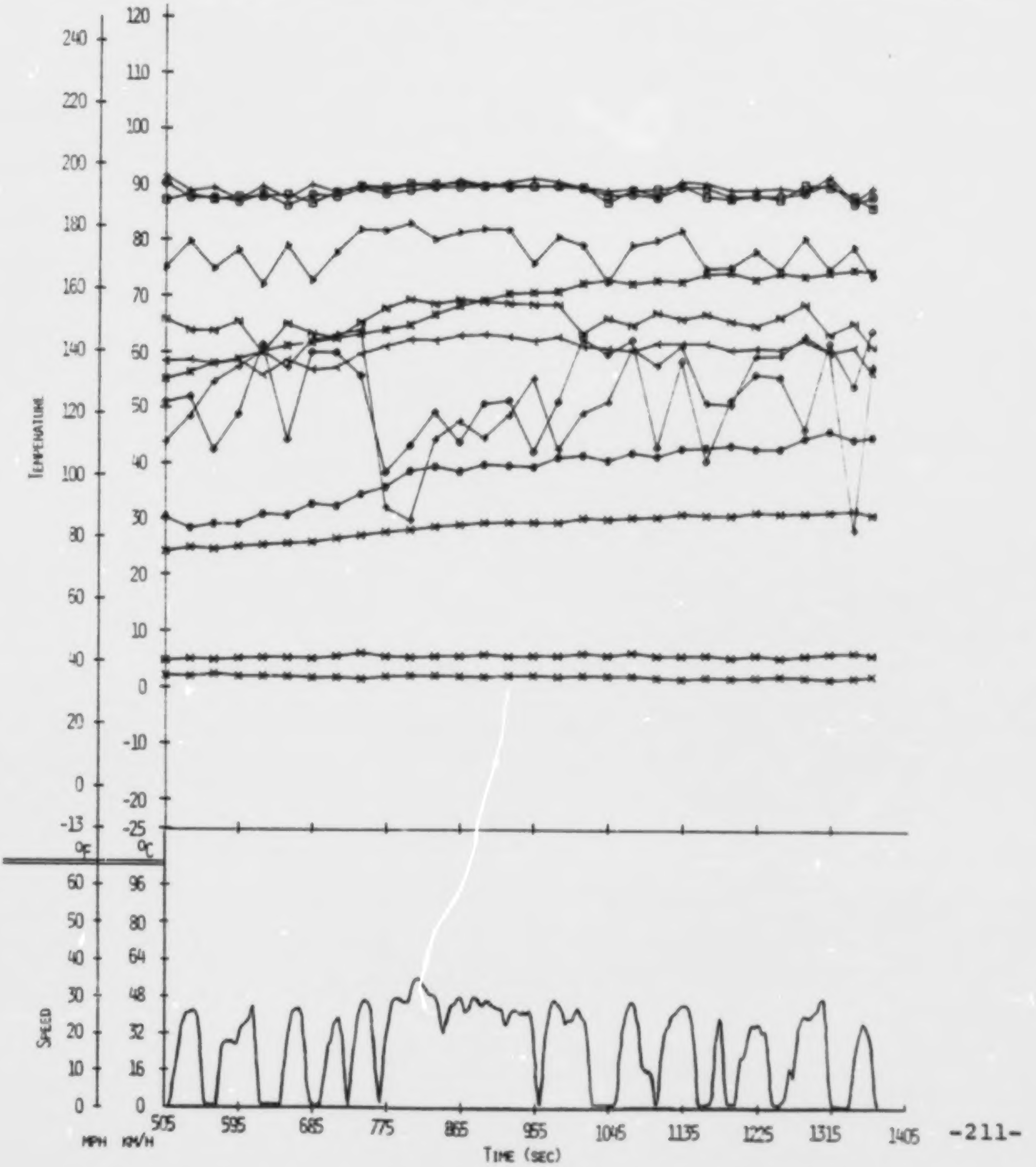
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
- + — Coolant - Thermostat
- ✦ — Coolant - Lower Rad. Hose
- ○ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⌑ — Eng. Oil @ Dipstick
- ● — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel - Vapourizer In
- ⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 96**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.3-1 TEST TEMPERATURE: 0 C

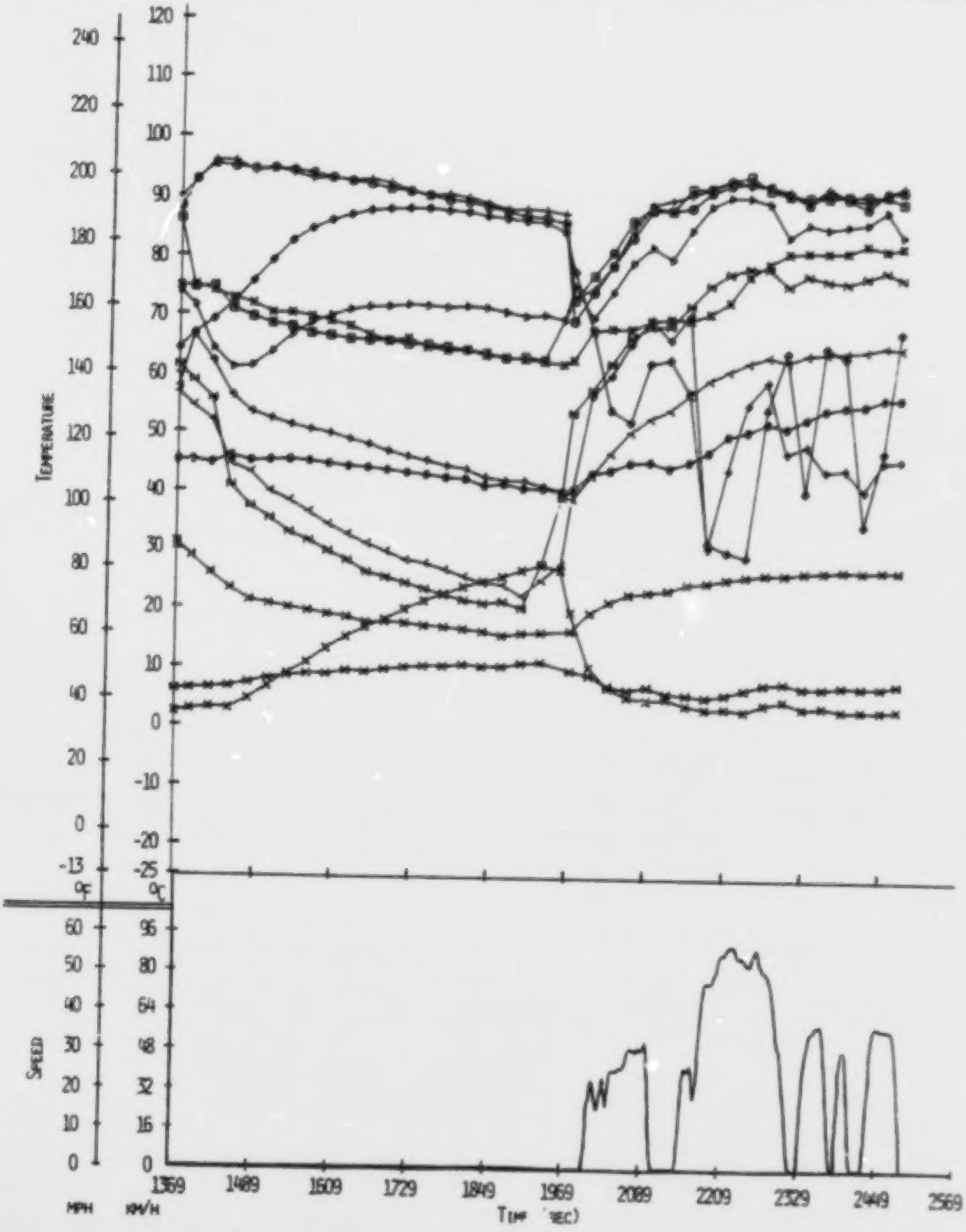
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION:A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118226

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
⊖ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
⊕ — Trans. Oil @ Dipstick
⤙ — Heater Duct - Left
₦ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizor In
⊡ — Coolant - Vapourizor Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 97**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.3-1 TEST TEMPERATURE: 0 C

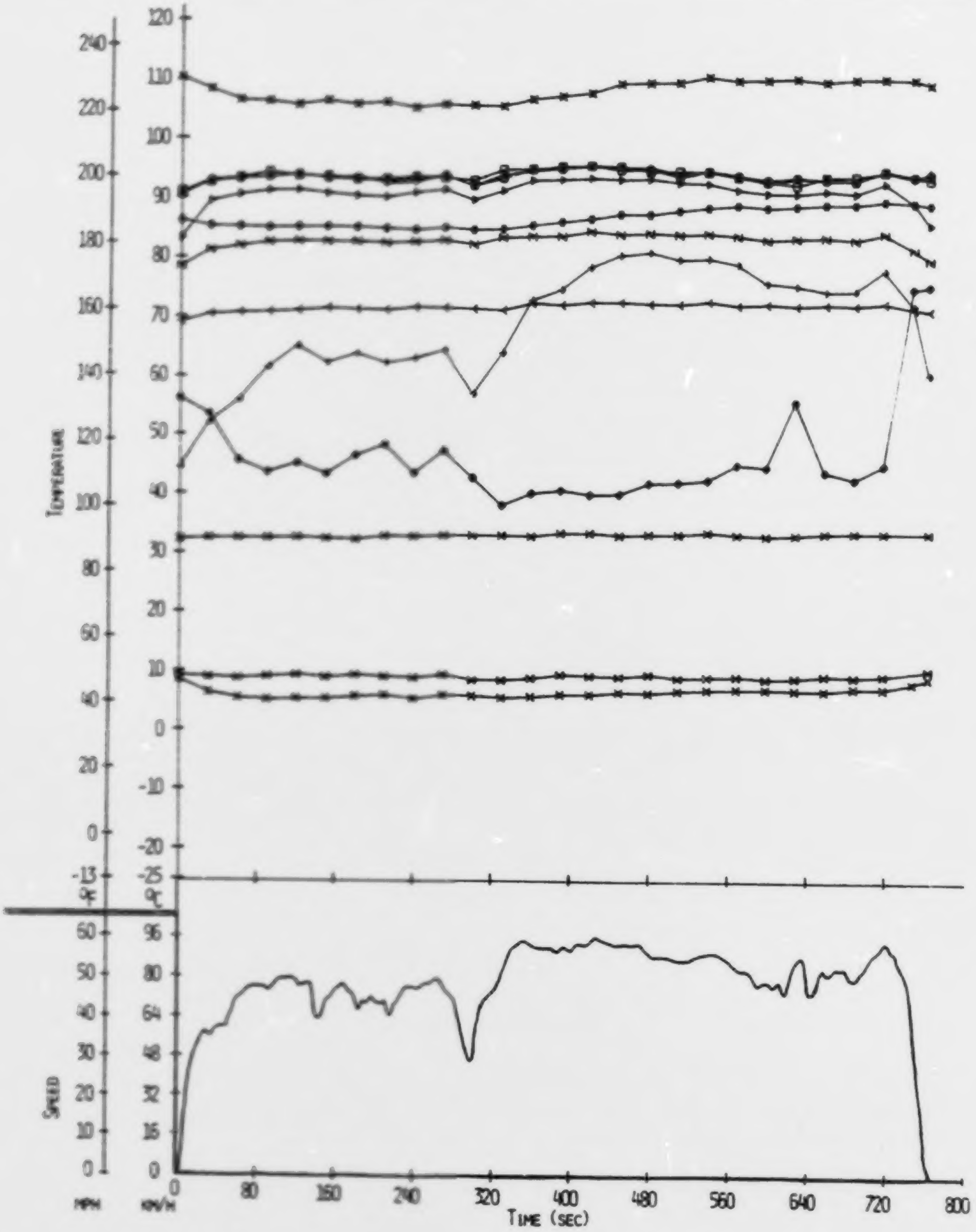
HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
□ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 98**

VEHICLE NO: 9 PROPANE TEST NO: 9.2.3-1 TEST TEMPERATURE: 0 C

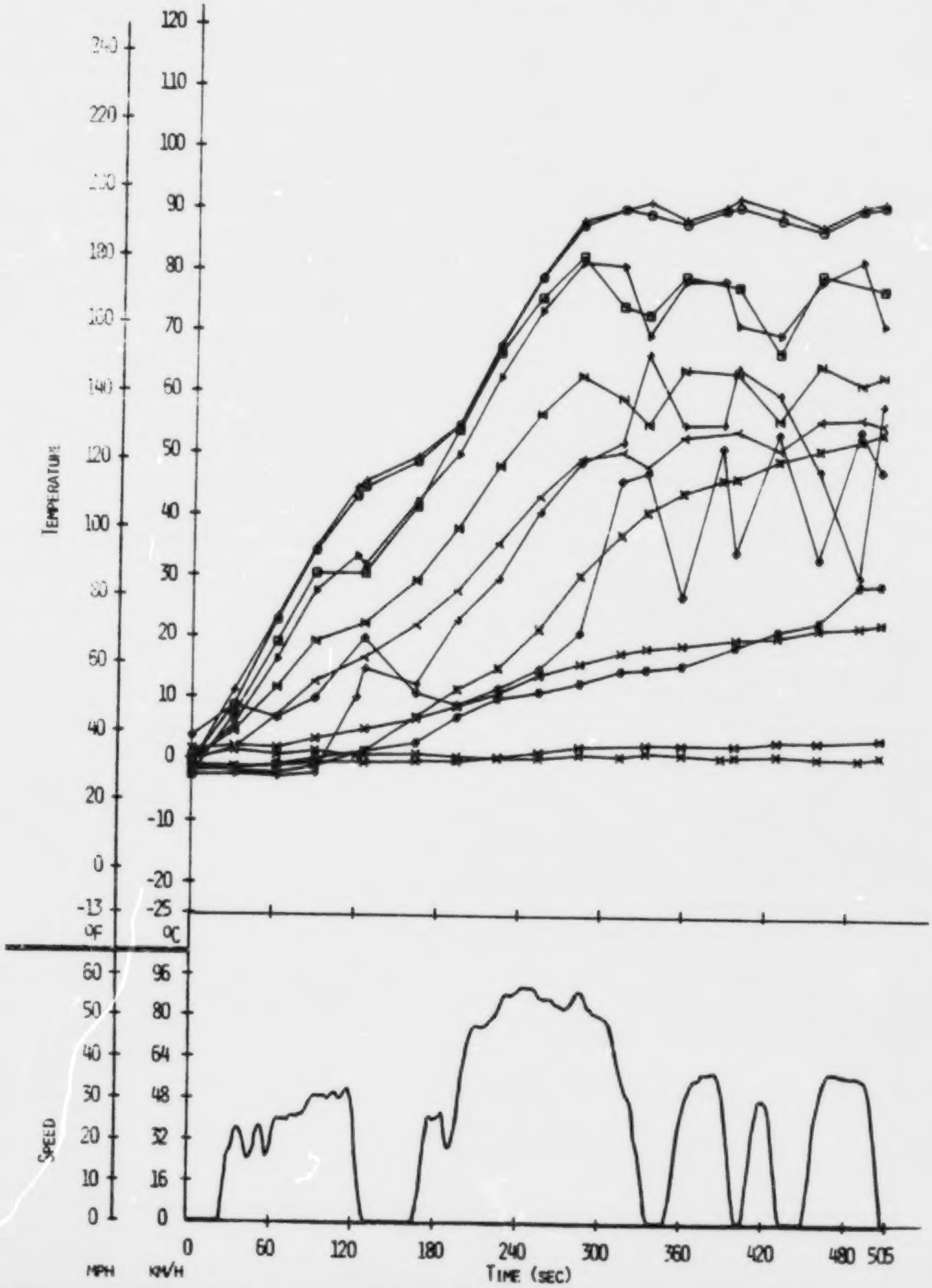
CITY CYCLE COLD TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 99**

VEHICLE NO: 9 PROPANE TEST NO: 9.2.3-1 TEST TEMPERATURE: 0 C

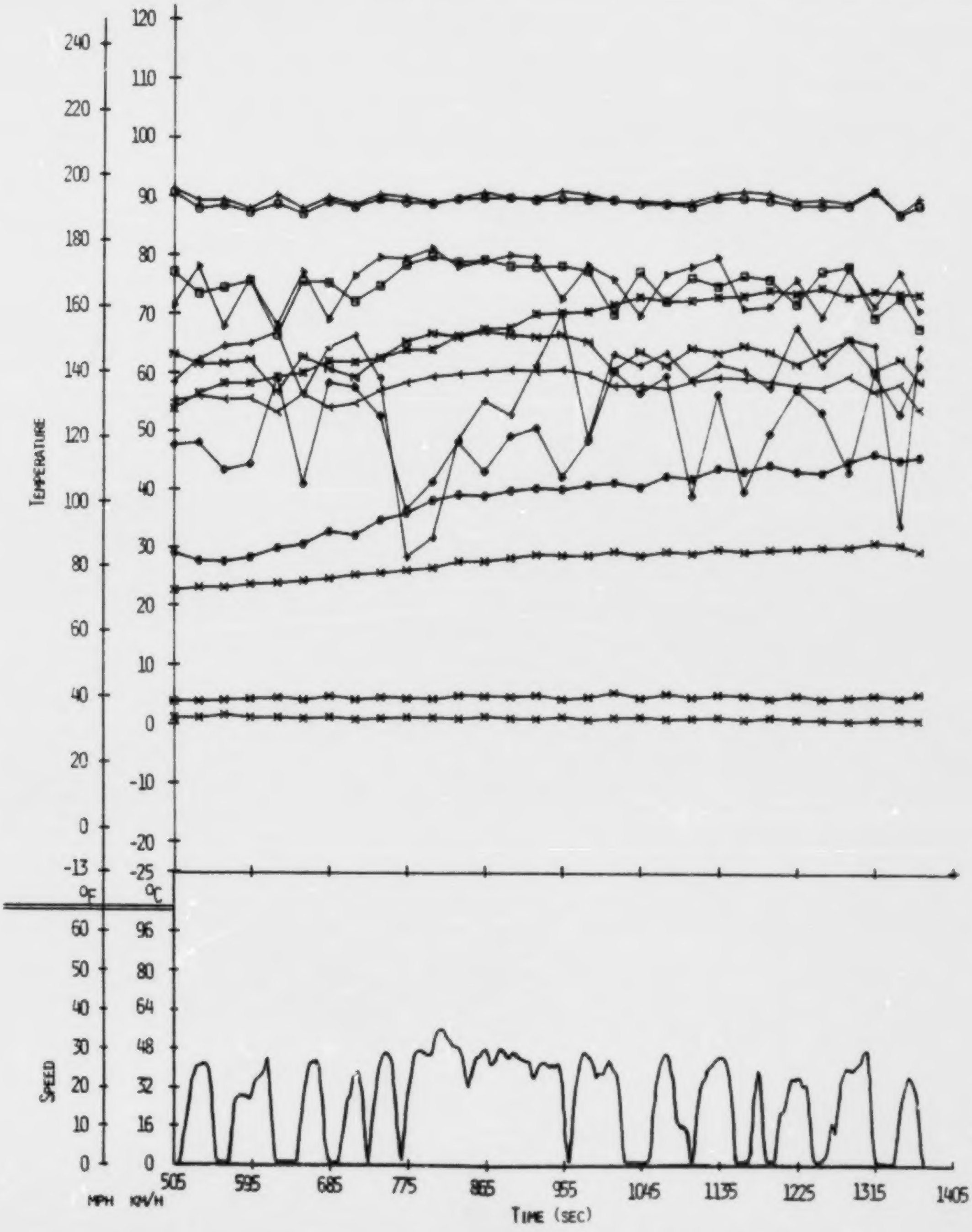
CITY CYCLE COLD STABILIZED TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
▣ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 100

VEHICLE NO: 9 PROPANE
TEST NO: 9.2.3-1
TEST TEMPERATURE: 0 °C

CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
♦ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
□ — Coolant - Vapourizer Out

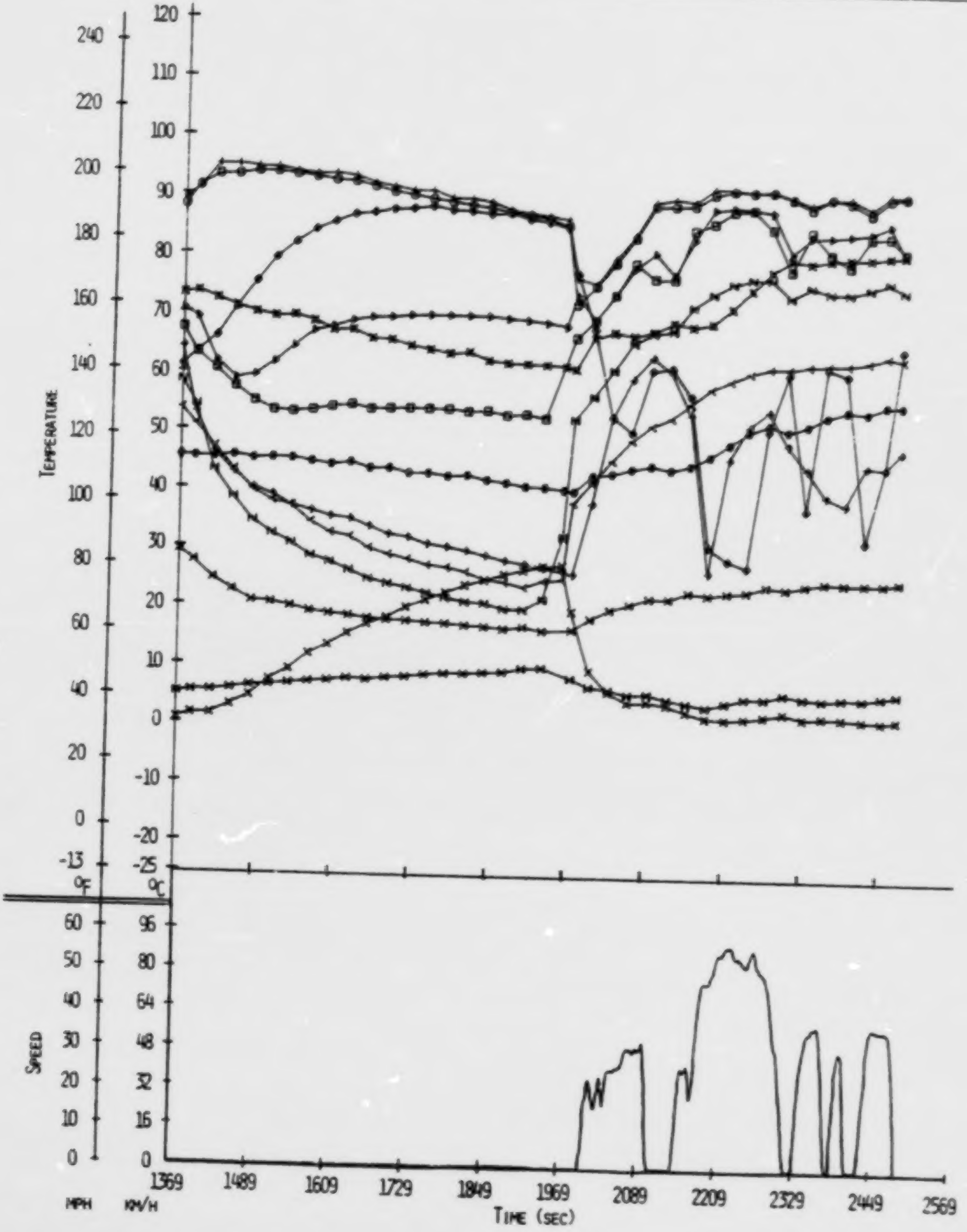


Figure 101

VEHICLE NO: 9 PROPANE TEST NO: 9.2.3-1 TEST TEMPERATURE: 0 C

HIGHWAY CYCLE
TEMPERATURE TRACE

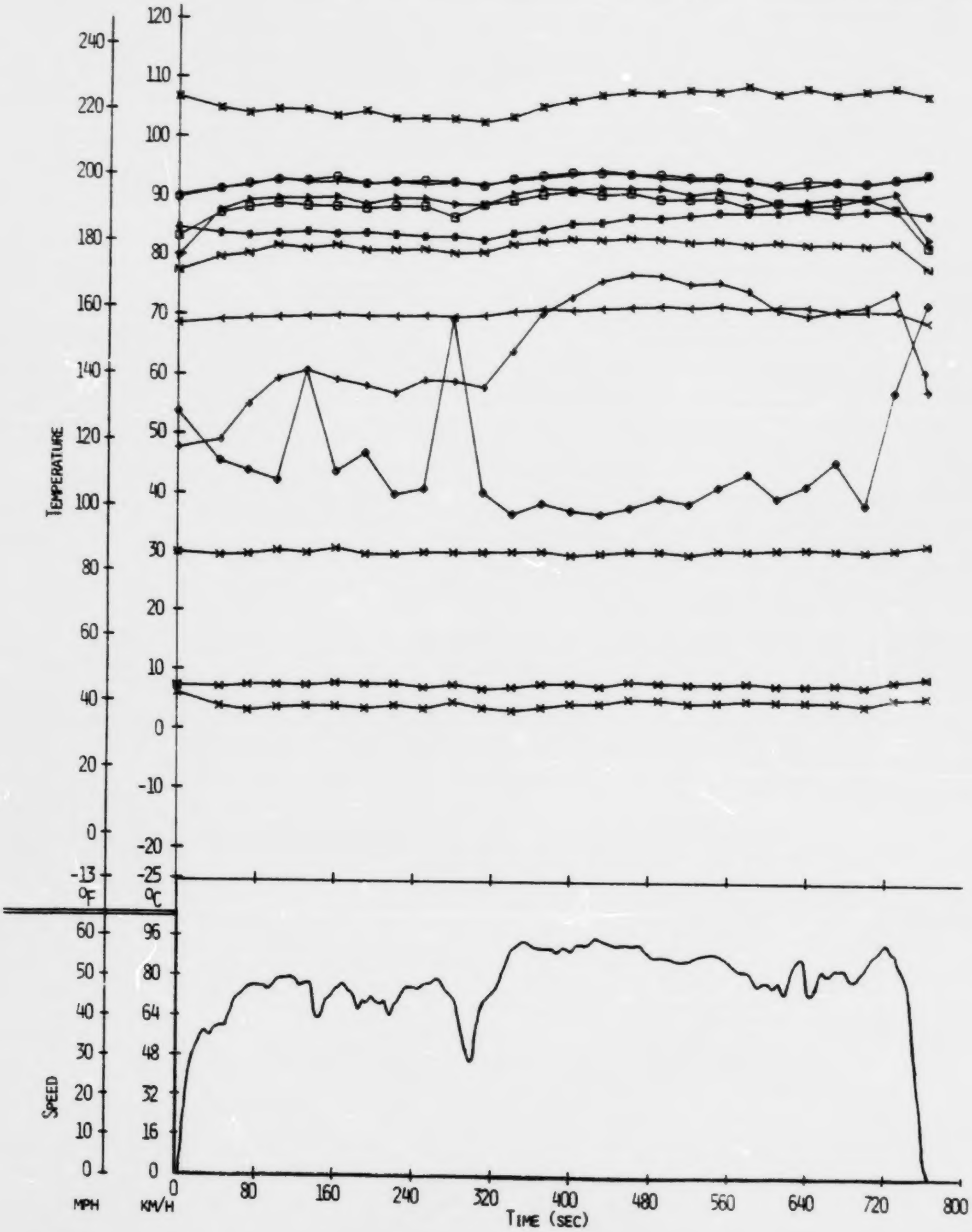
HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
◯ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 102**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4-1 TEST TEMPERATURE: -20 C

CITY CYCLE COLD TRANSIENT TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

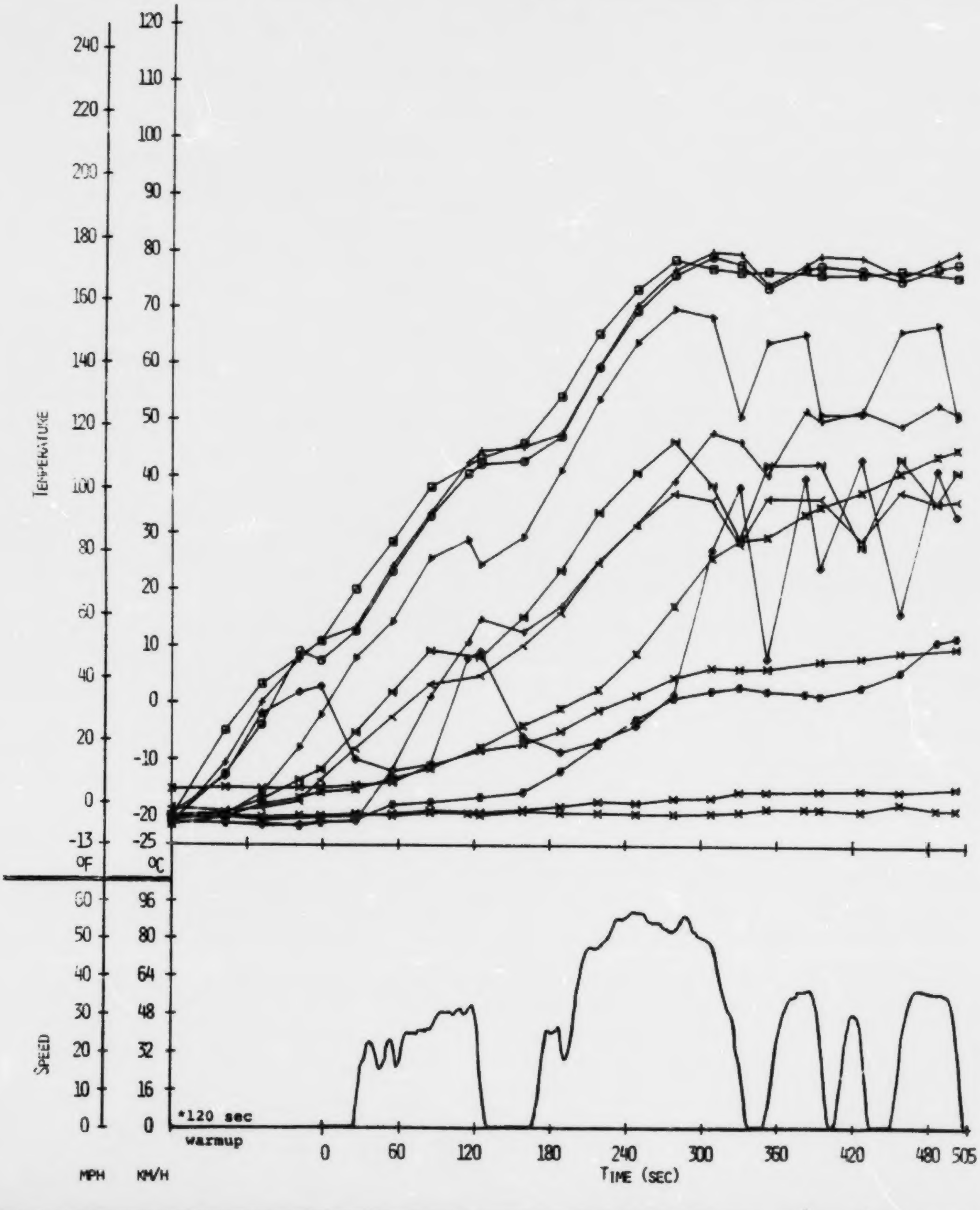
Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

*An additional 120 sec idle period was performed prior to the start of the actual test cycle.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
< — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 103

VEHICLE NO: 9 PROPANE
TEST NO: 9.1.4-1
TEST TEMPERATURE: -20 C

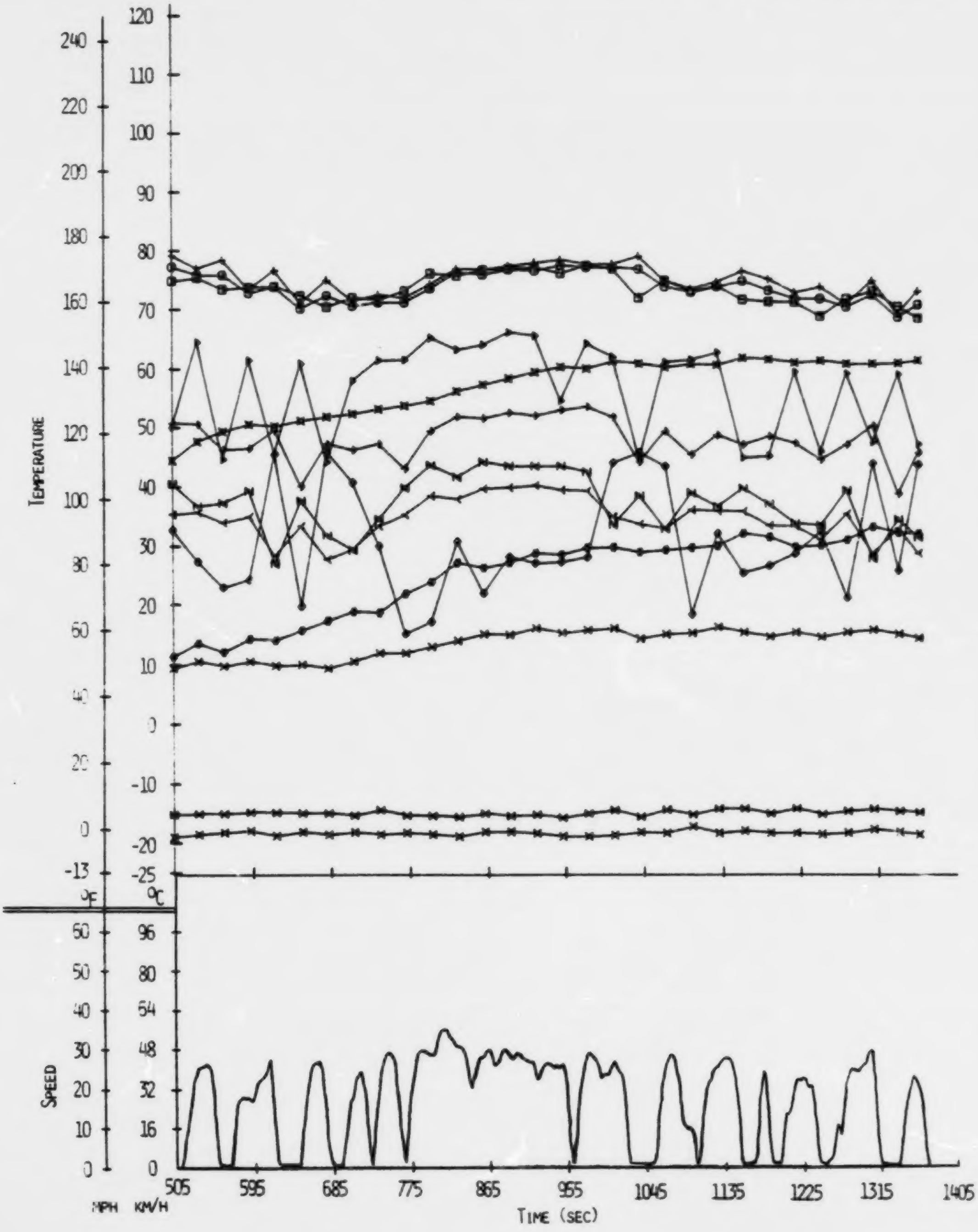
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✥ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 104

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4-1 TEST TEMPERATURE: -20 C

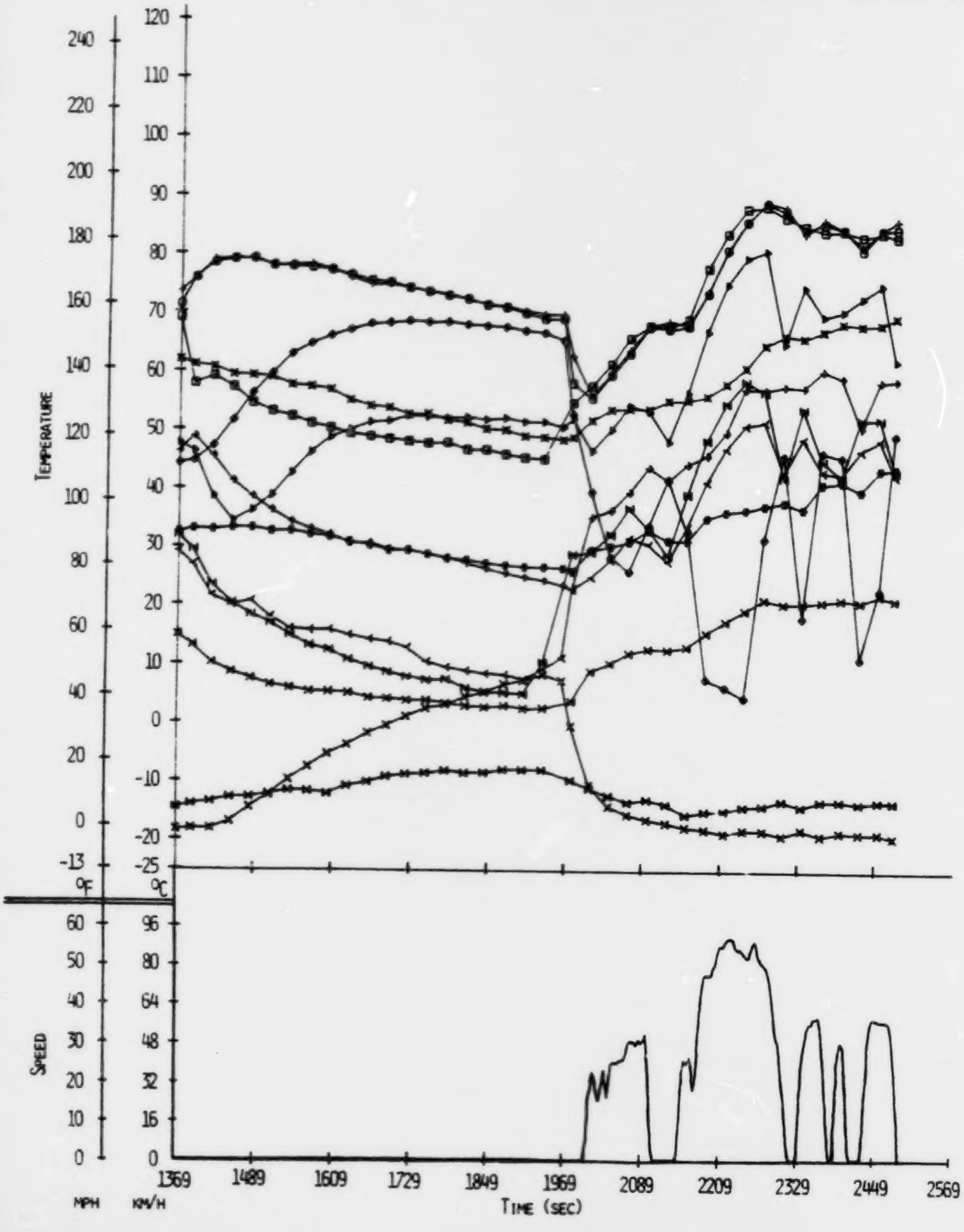
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 105**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4-1 TEST TEMPERATURE: -20 C

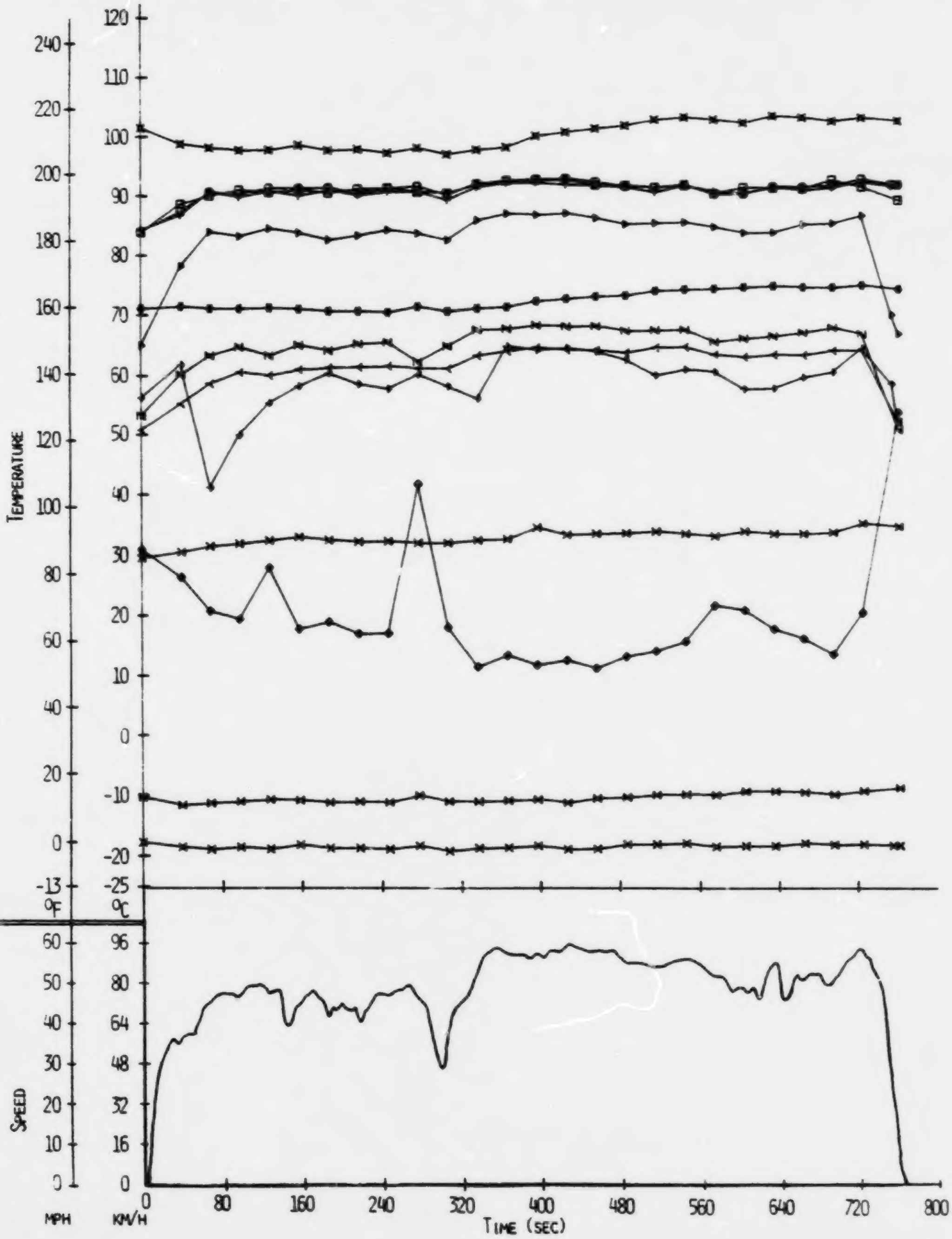
HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⇸ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✥ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 106**

VEHICLE NO: 9 PROPANE   TEST NO: 9.2.4-1   TEST TEMPERATURE: -20 C

CITY CYCLE COLD TRANSIENT TEMPERATURE TRACE

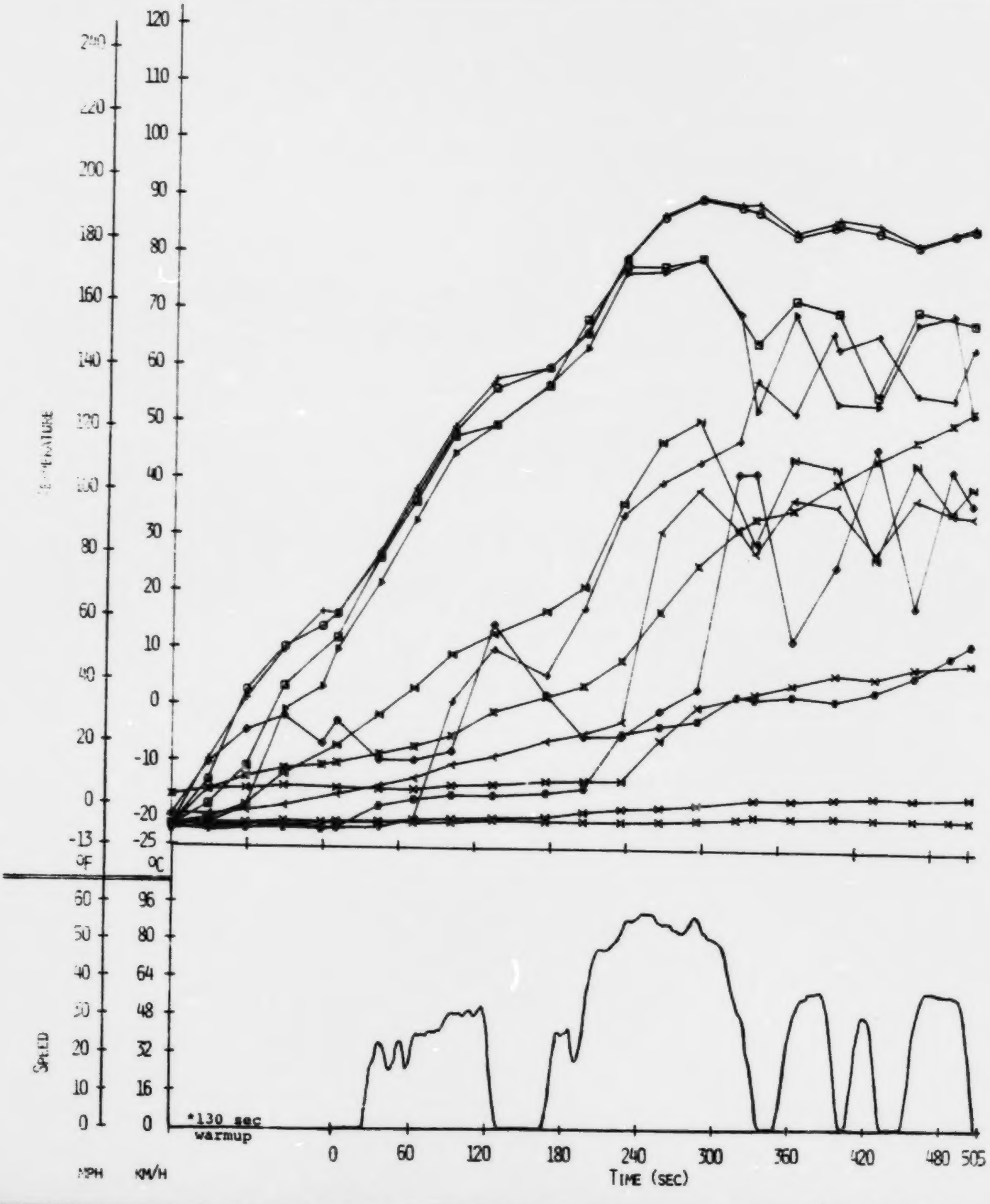
HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

*An additional 130 sec idle period was performed prior to the start of the actual test cycle.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
➔ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✤ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
₦ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 107**

VEHICLE NO: 9 PROPANE TEST NO: 9.2.4-1 TEST TEMPERATURE: -20

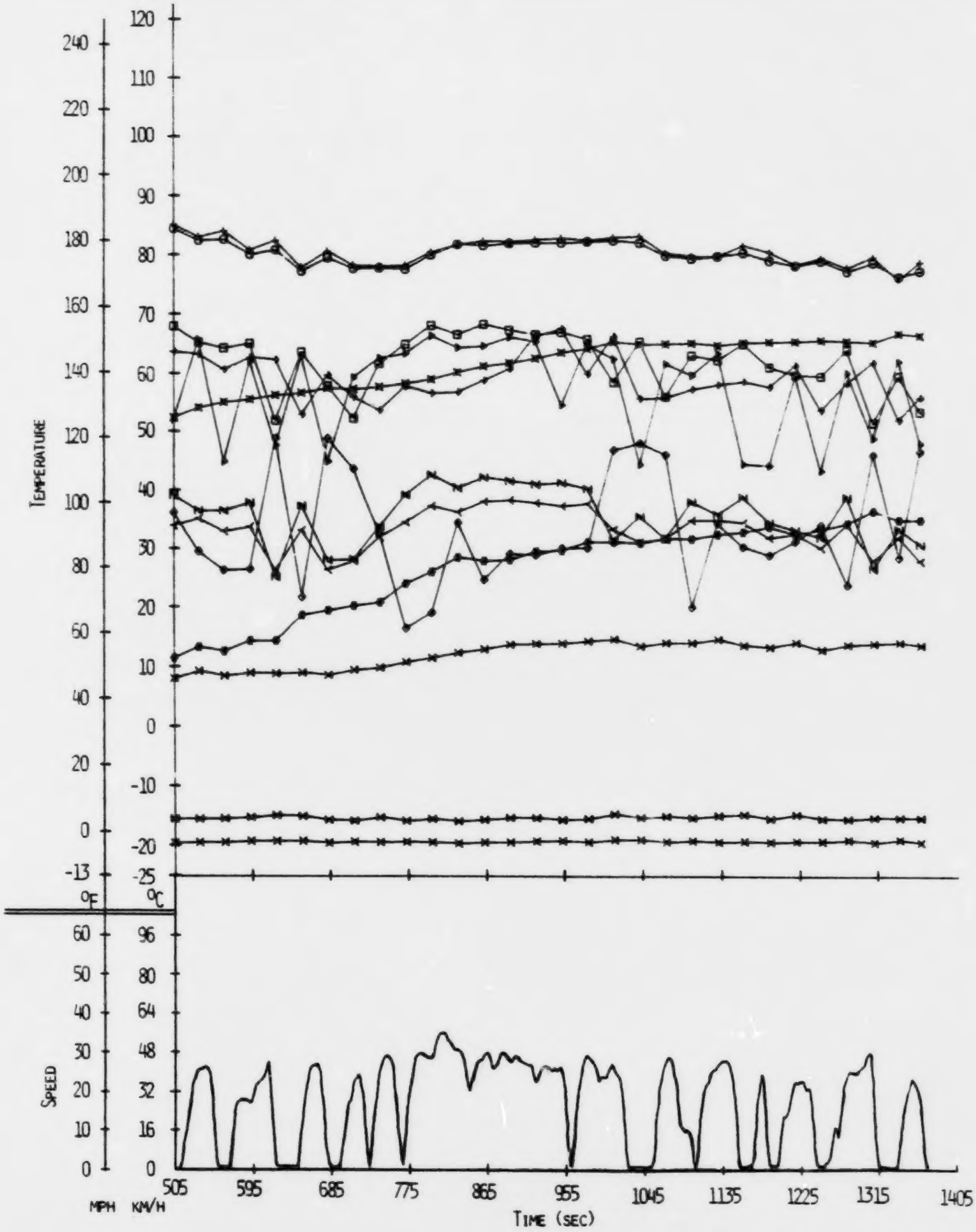
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⬖ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 108

VEHICLE NO: 9 PROPANE

TEST NO: 9.2.4-1

TEST TEMPERATURE: -20 C

CITY CYCLE SOAK & HOT TRANSIENT TEMPERATURE TRACE

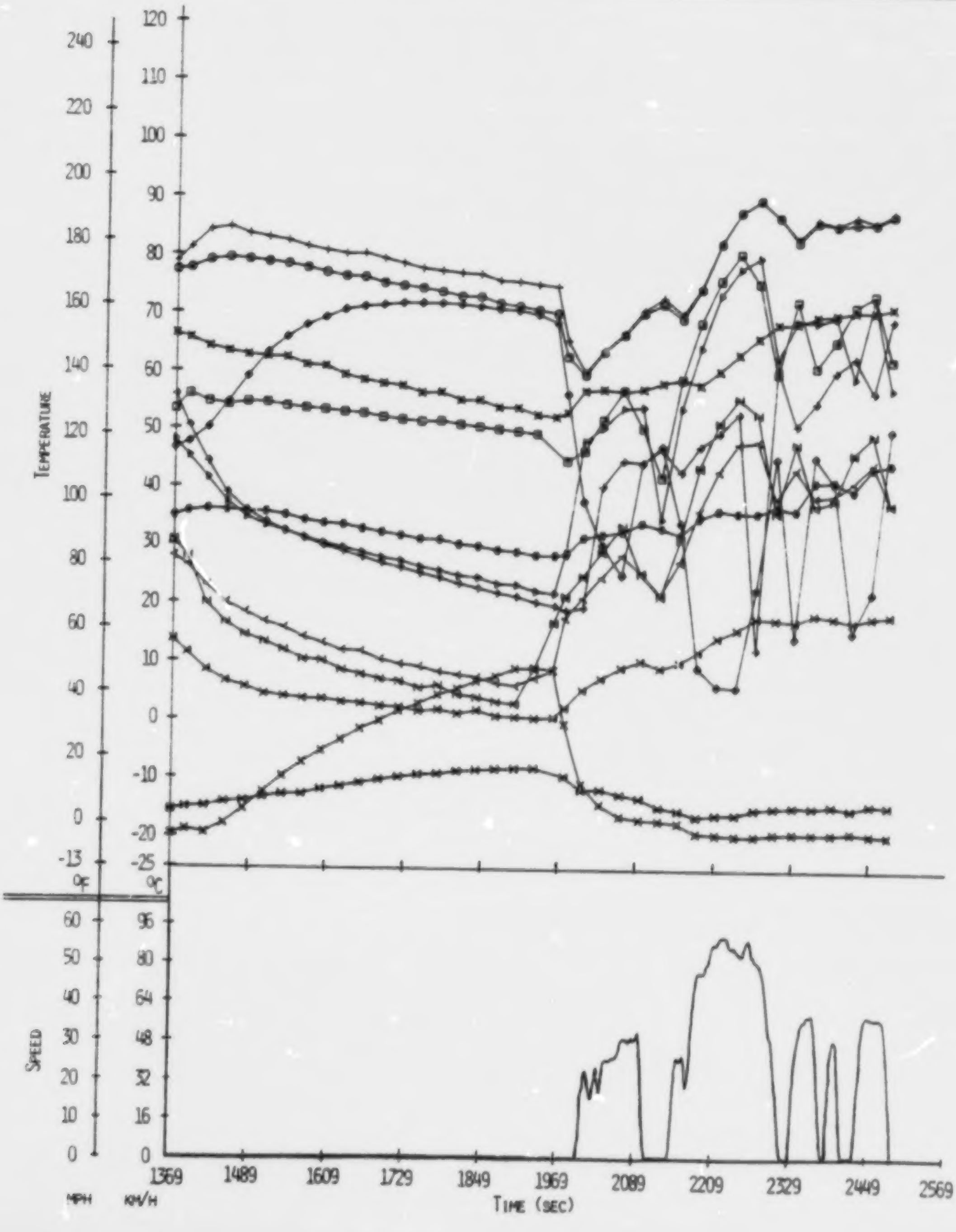
HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
▣ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
≻ — Heater Duct - Right
⋈ — In Car Temp.
⧓ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 109**

VEHICLE NO: 9 PROPANE TEST NO: 9.2.4-1 TEST TEMPERATURE: -20 C

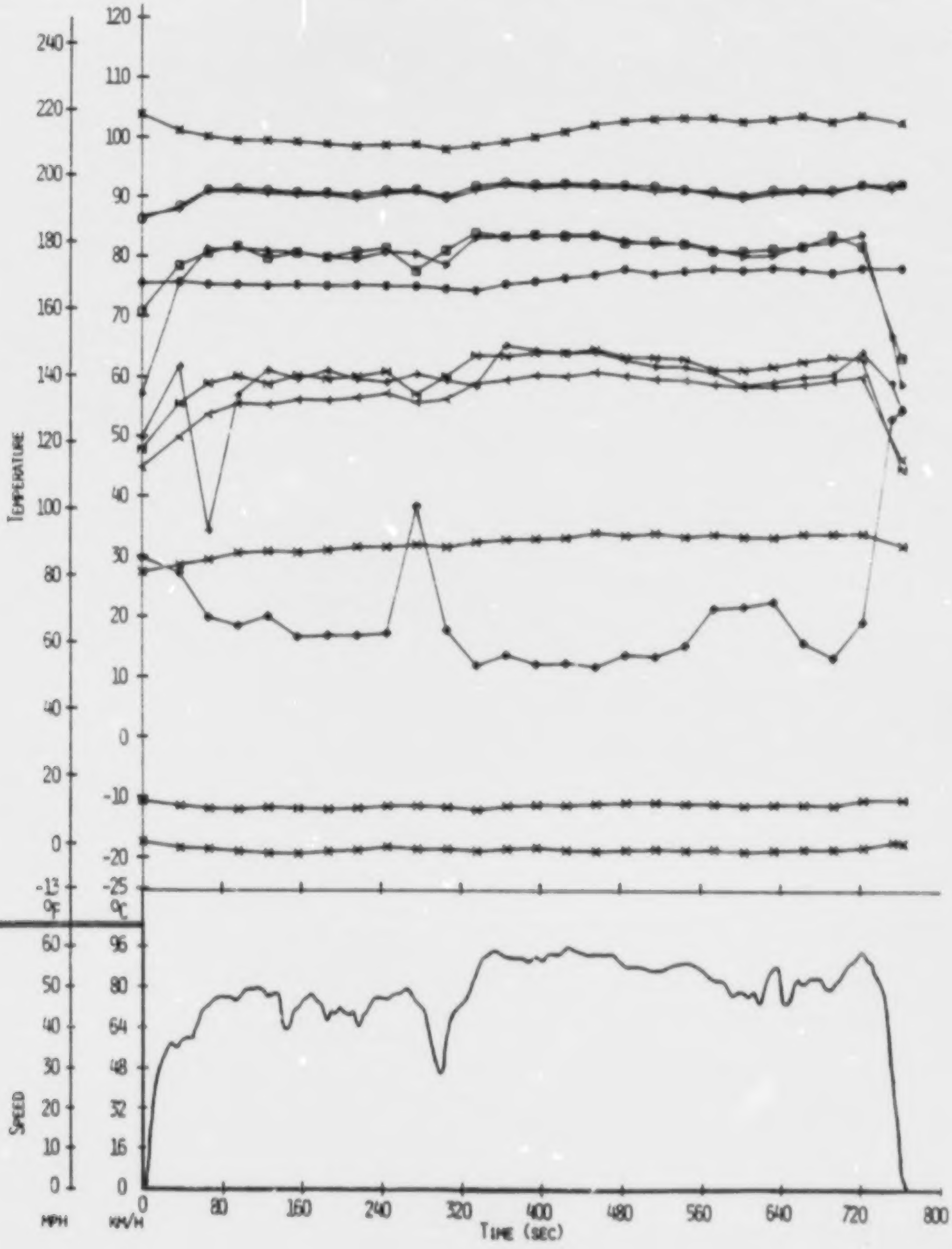
HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION: B - VAPOURIZER COOLANT FLOW IN SERIES WITH HEATER RETURN

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
▣ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 110

VEHICLE NO: 9 PROPANE

TEST NO: 9.1.4B-2

TEST TEMPERATURE: -20 C

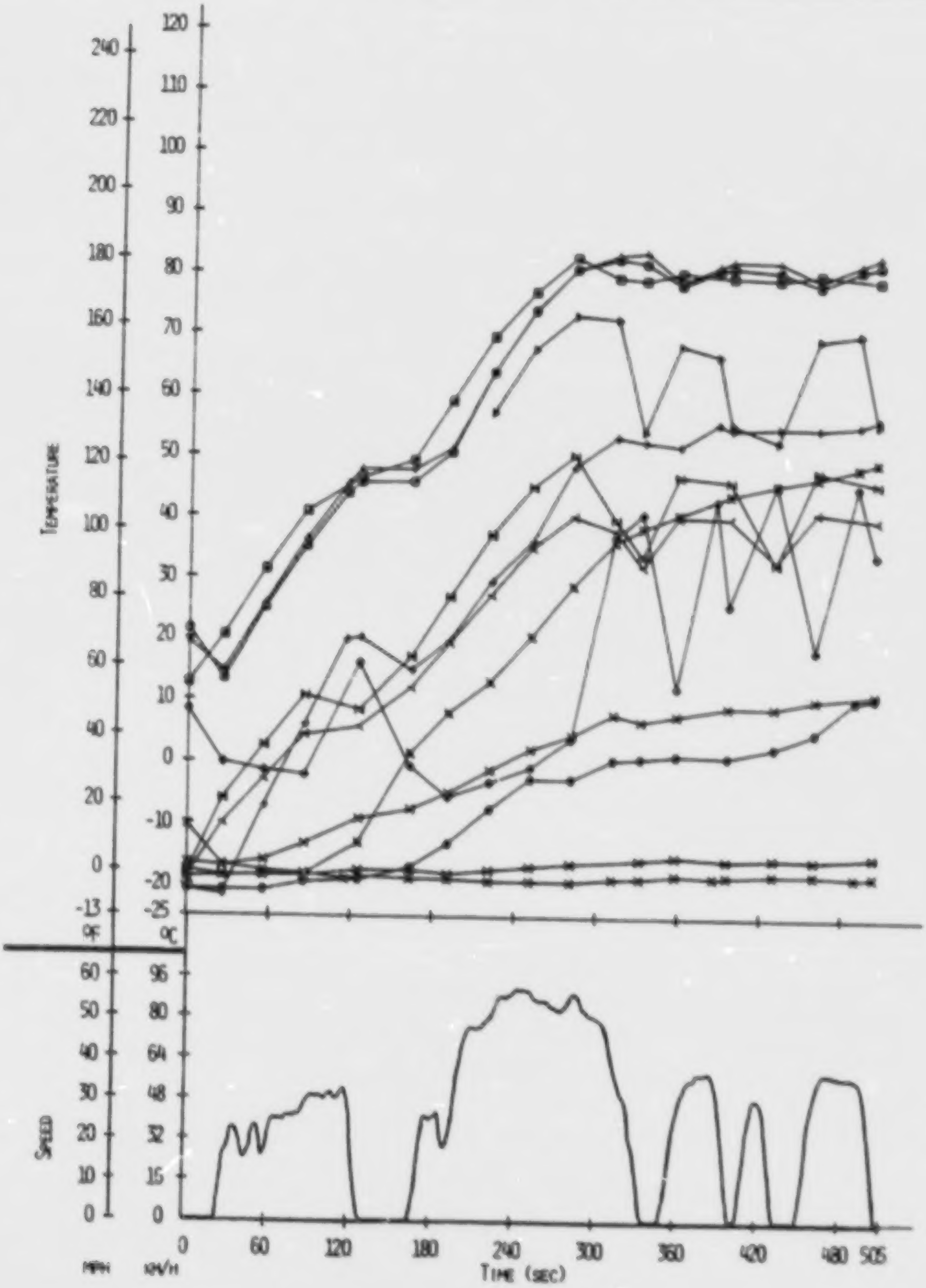
CITY CYCLE COLD TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⊠ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 111**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4B-2 TEST TEMPERATURE: -20 C

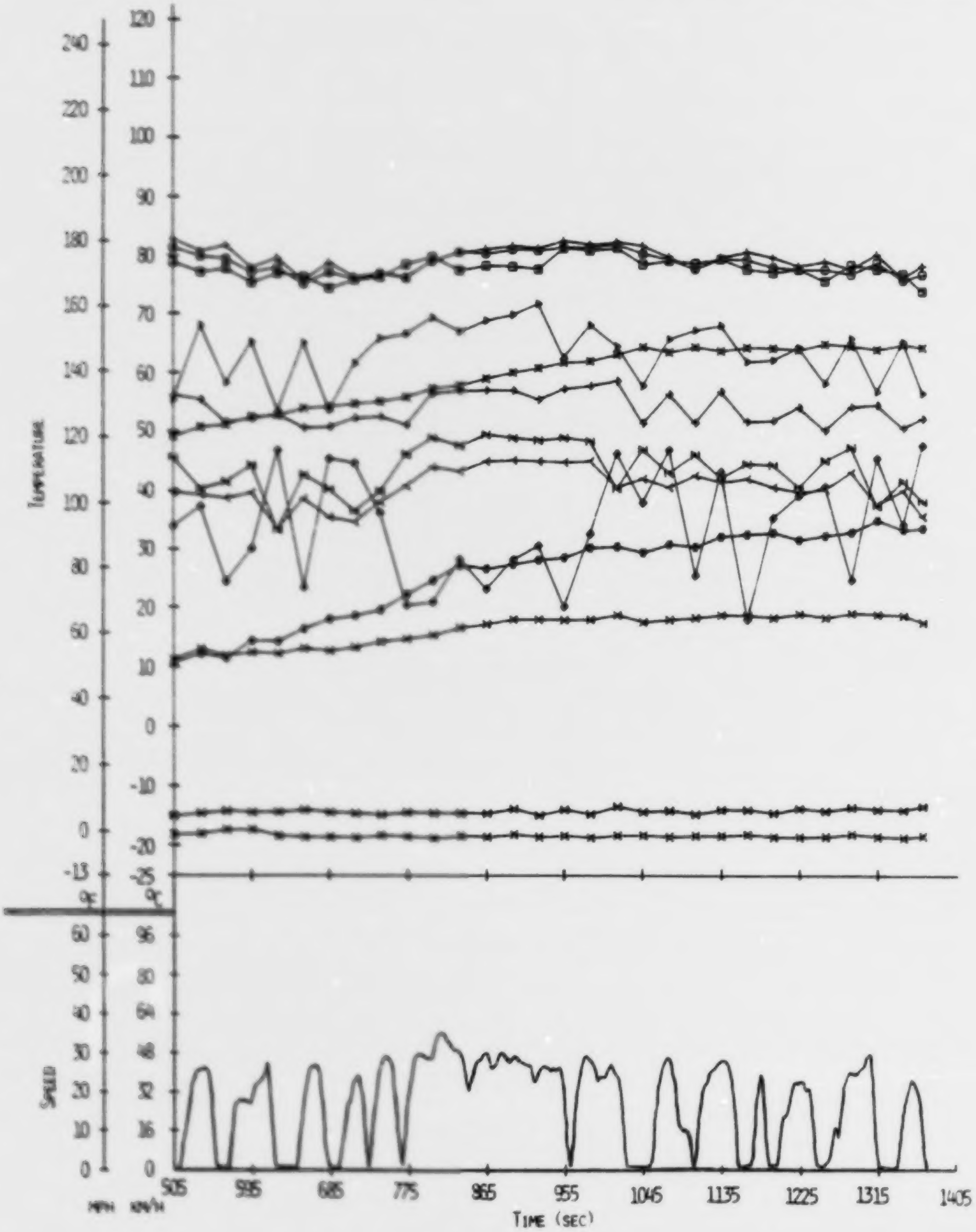
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
- + — Coolant - Thermostat
- ✦ — Coolant - Lower Rad. Hose
- ○ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⌑ — Eng. Oil @ Dipstick
- ✿ — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel - Vapourizer In
- ⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 112

VEHICLE NO: 9 PROPANE

TEST NO: 9.1.4B-2

TEST TEMPERATURE: -20 C

CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

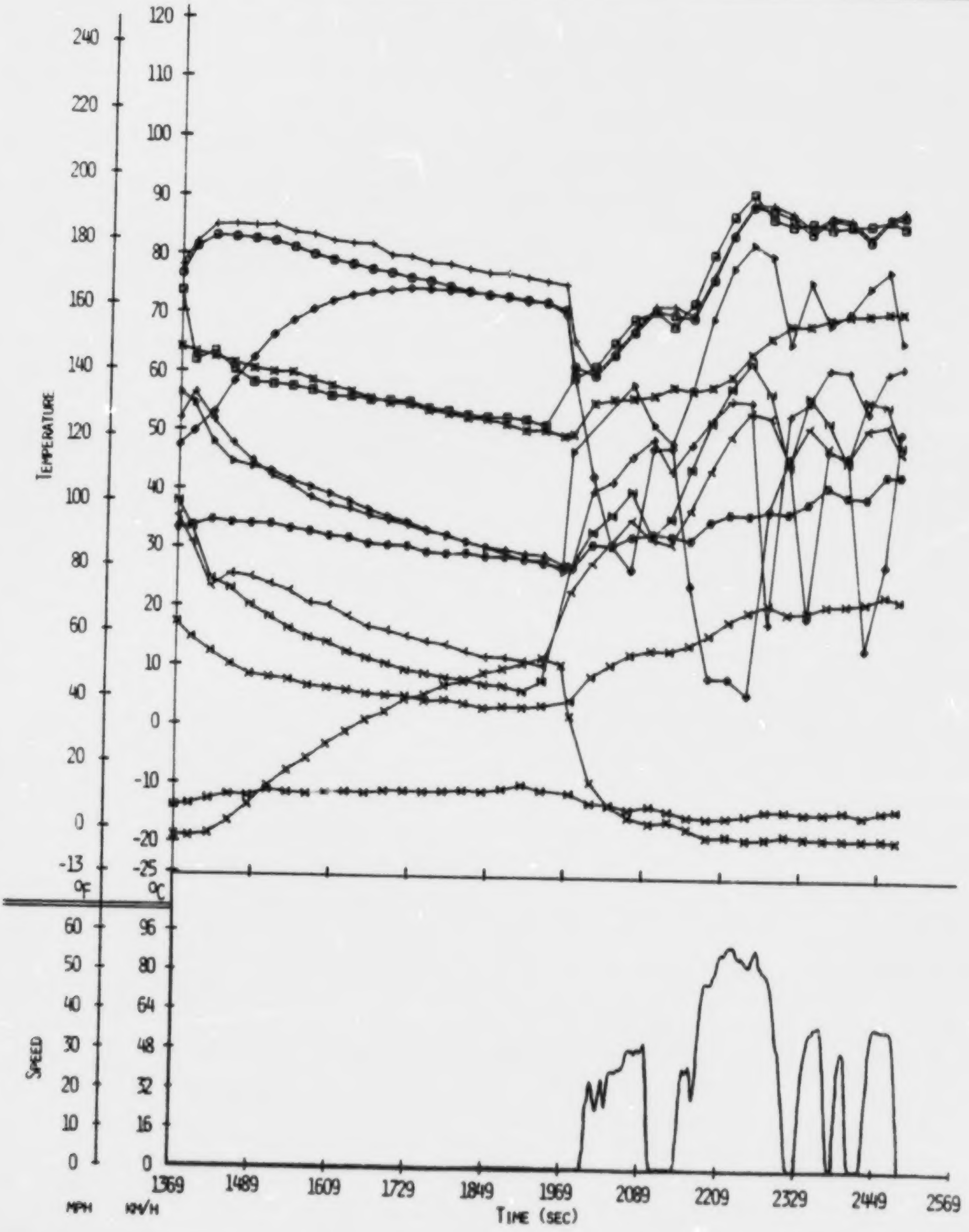
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. In
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
⚙ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
₪ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 113

VEHICLE NO: 9 PROPANE   TEST NO: 9.1.4B-2   TEST TEMPERATURE: -20 C

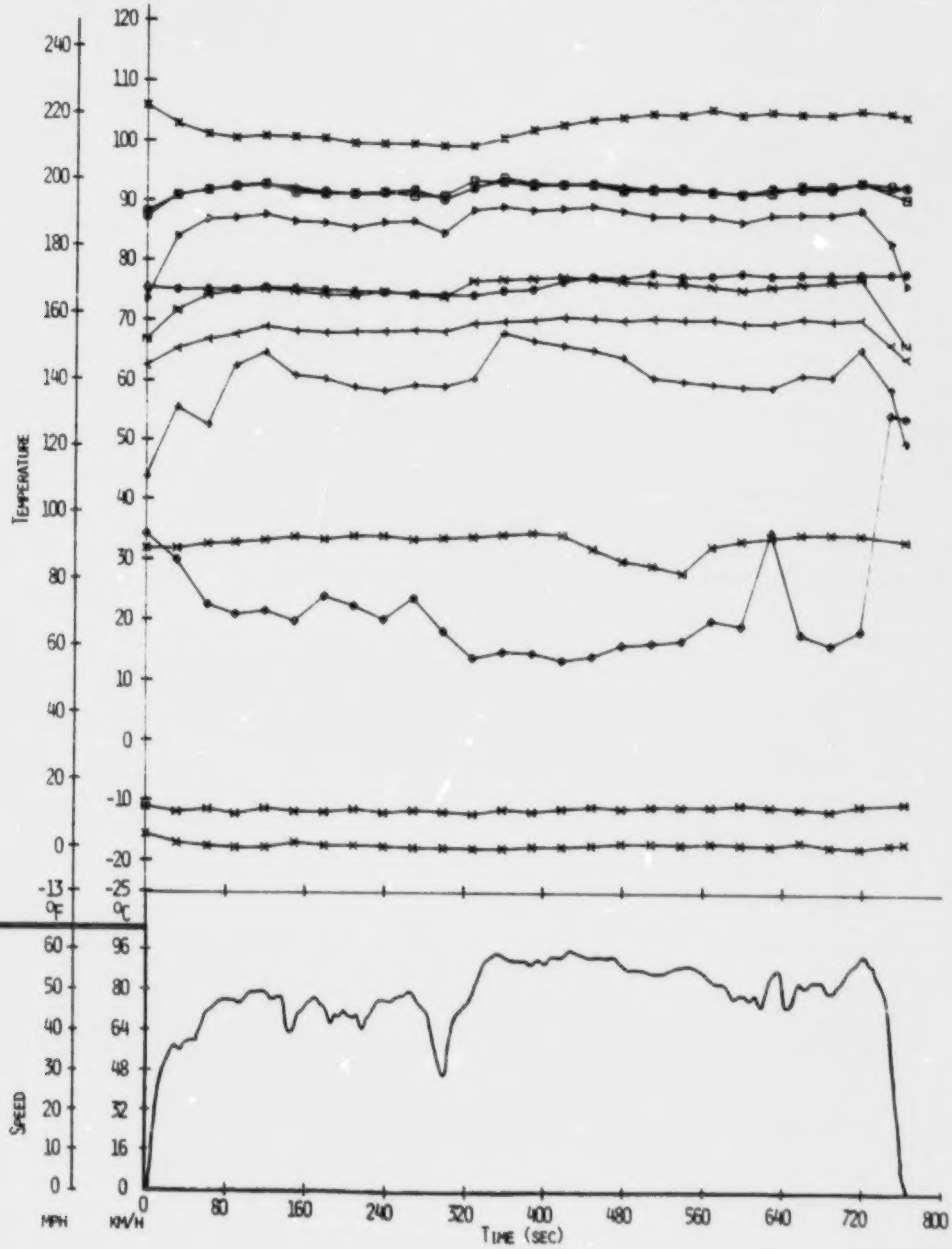
HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION:A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
⚙ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
Ŋ — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 114

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4C-1 TEST TEMPERATURE: -20 C

CITY CYCLE COLD TRANSIENT
TEMPERATURE TRACE

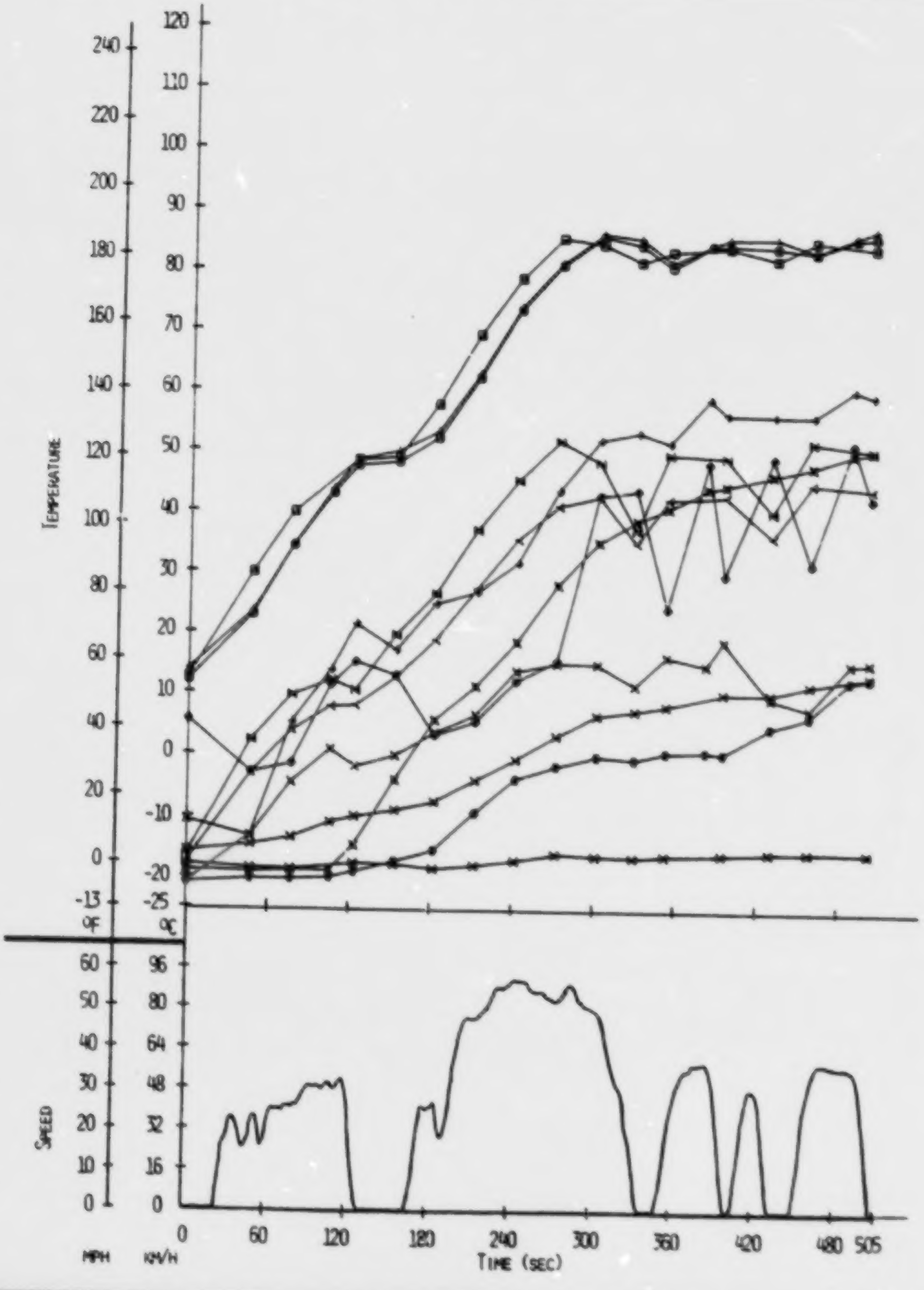
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS *

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

* WITH HEATED INTAKE AIR

LEGEND (VEHICLE 9)
- + — Coolant - Thermostat
- ⊕ — Coolant - Lower Rad. Hose
- ○ — Coolant - Heater In
- ▷ — Coolant - Heater Out
- × — Carb. Air In
- ◇ — Int. Manifold Runner
- ⌑ — Eng. Oil @ Dipstick
- ✪ — Trans. Oil @ Dipstick
- ≺ — Heater Duct - Left
- ⋈ — Heater Duct - Right
- ⋊ — In Car Temp.
- ⋈ — Fuel - Vapourizer In
- ⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 115

VEHICLE NO: 9 PROPANE   TEST NO: 9.1.4C-1   TEST TEMPERATURE: -20 C

CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

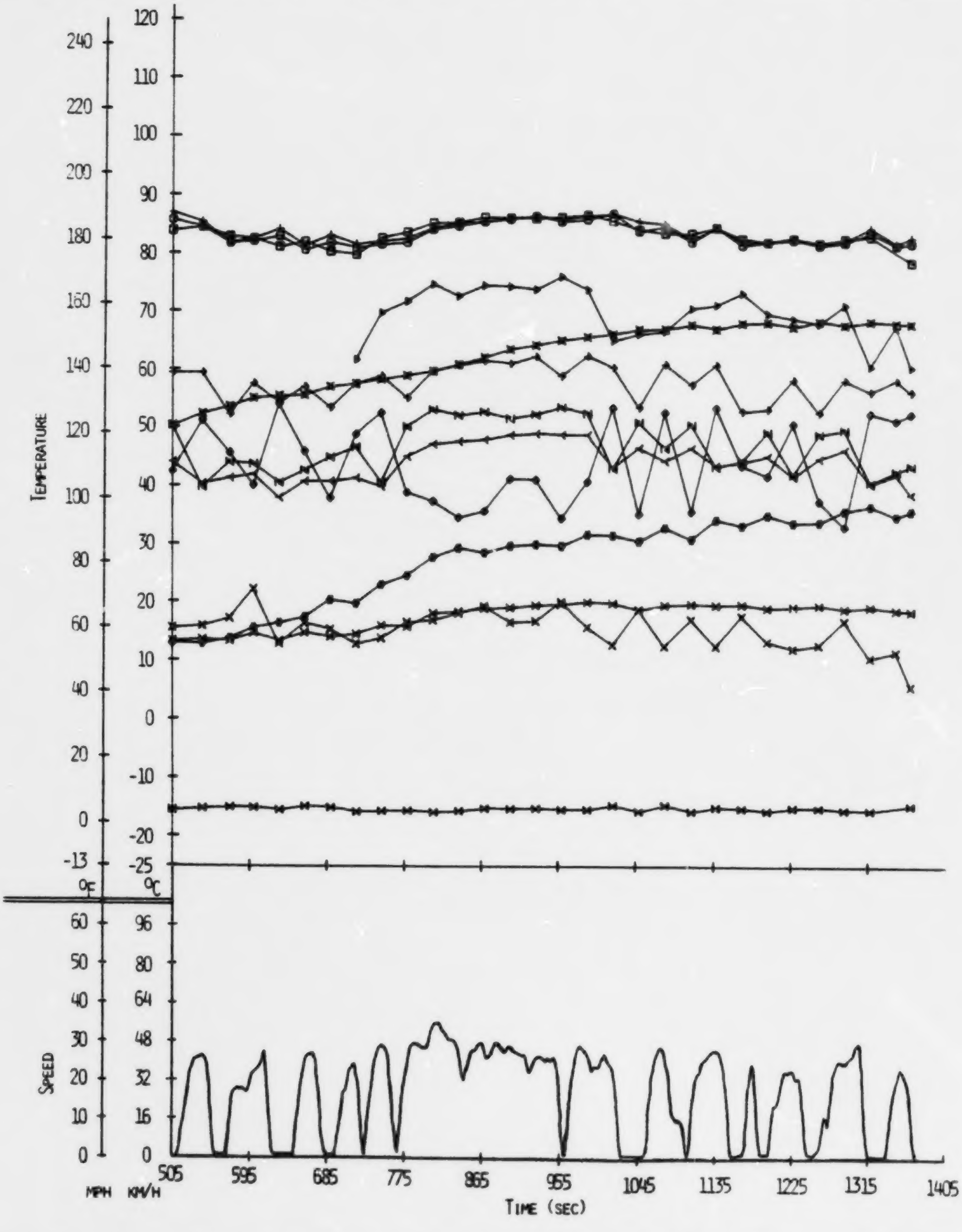
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS *

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

* WITH HEATED INTAKE AIR

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✢ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✿ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 116**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.4C-1 TEST TEMPERATURE: -20 C

CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

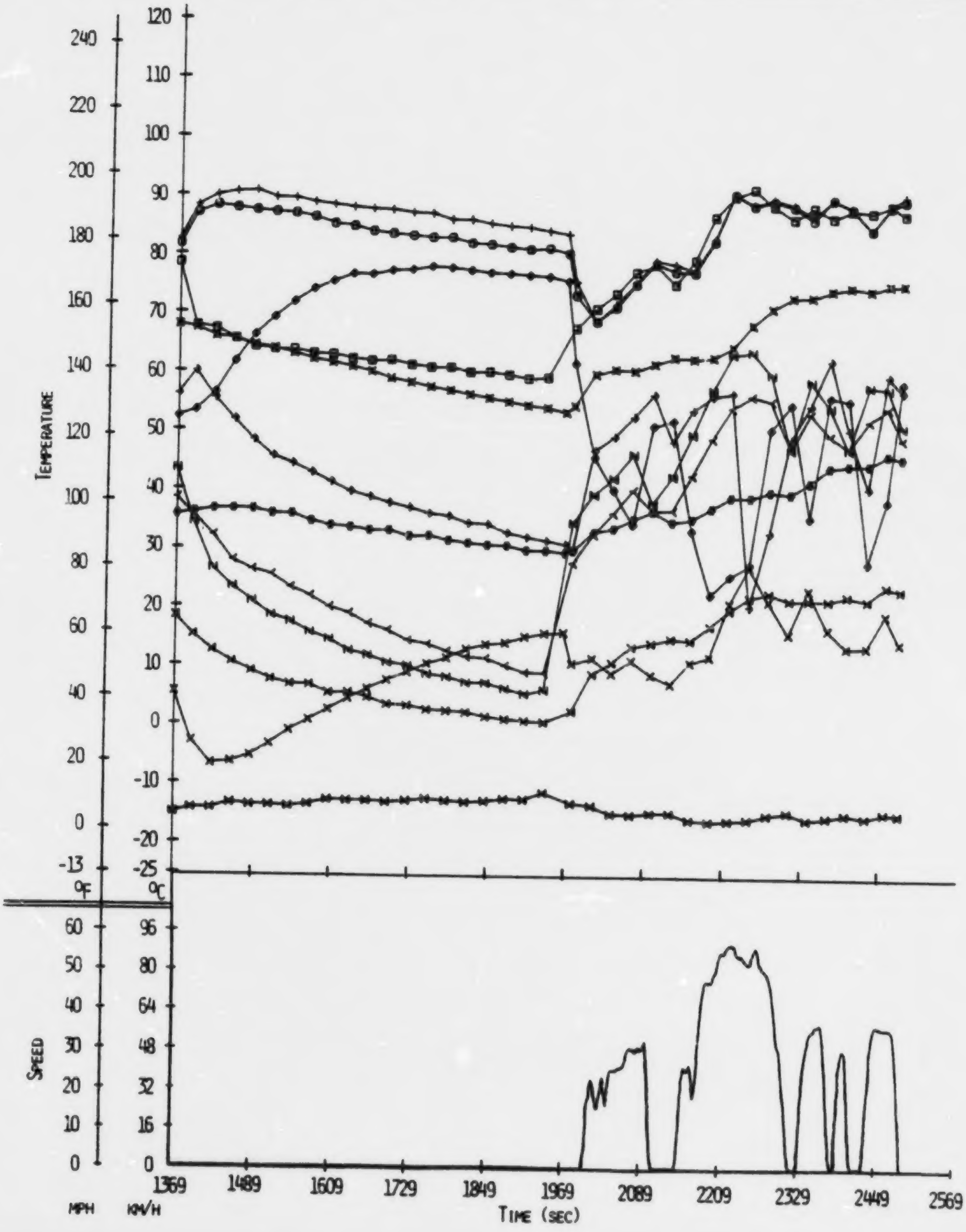
HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS *

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

* WITH HEATED INTAKE AIR

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 117

VEHICLE NO: 9 PROPANE

TEST NO: 9.1.4C-1

TEST TEMPERATURE: -20 C

HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION:A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 2 HOURS *

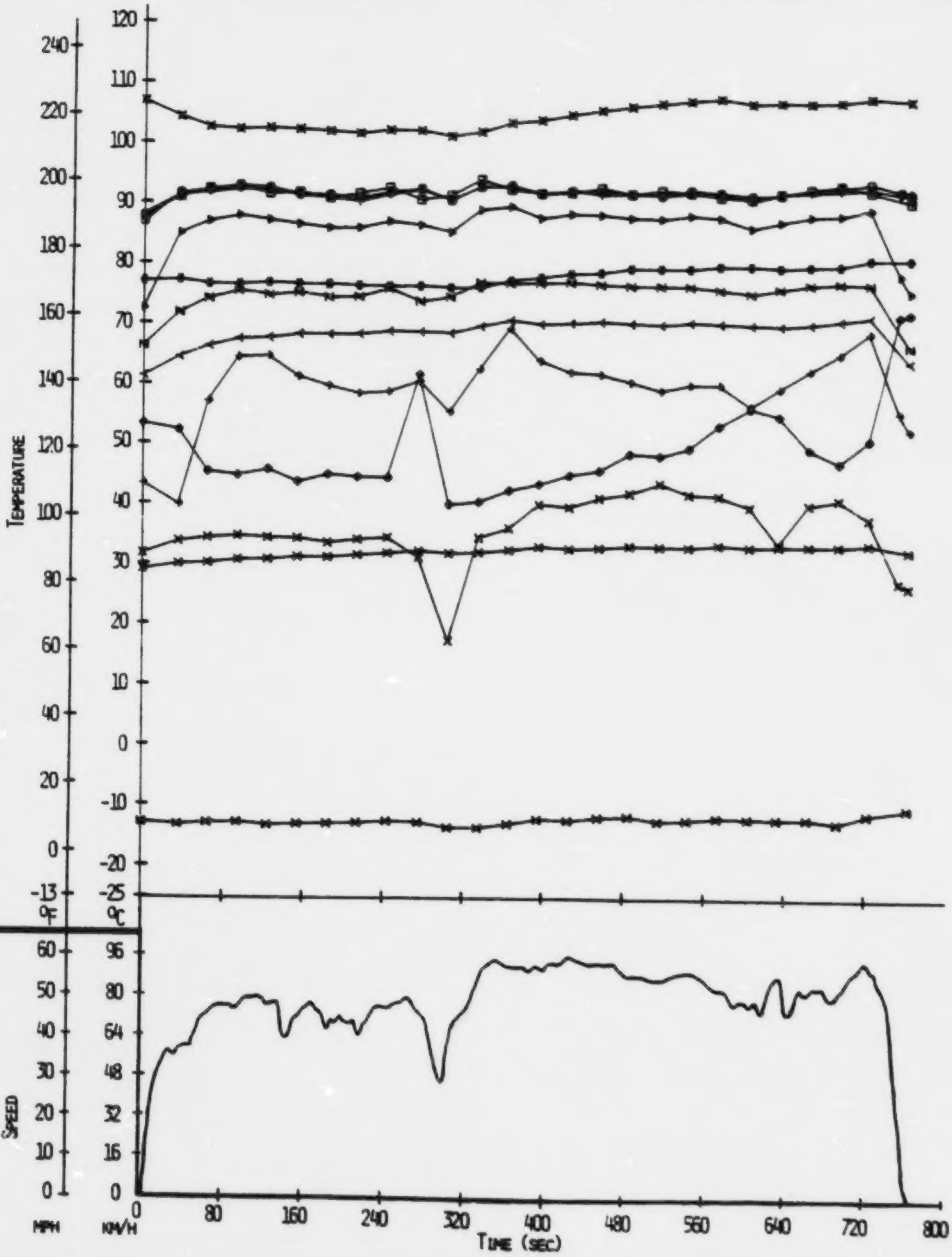
Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

* WITH HEATED INTAKE AIR

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
⊕ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋈ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 118**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.5-3 TEST TEMPERATURE: -35 C

CITY CYCLE COLD TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS, VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS W / BLOCK HEATER ON 5 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine, Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature. * An additional 150 sec idle period was performed prior to the start of the actual test cycle.

LEGEND (VEHICLE 9)

+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✣ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
□ — Coolant - Vapourizer Out

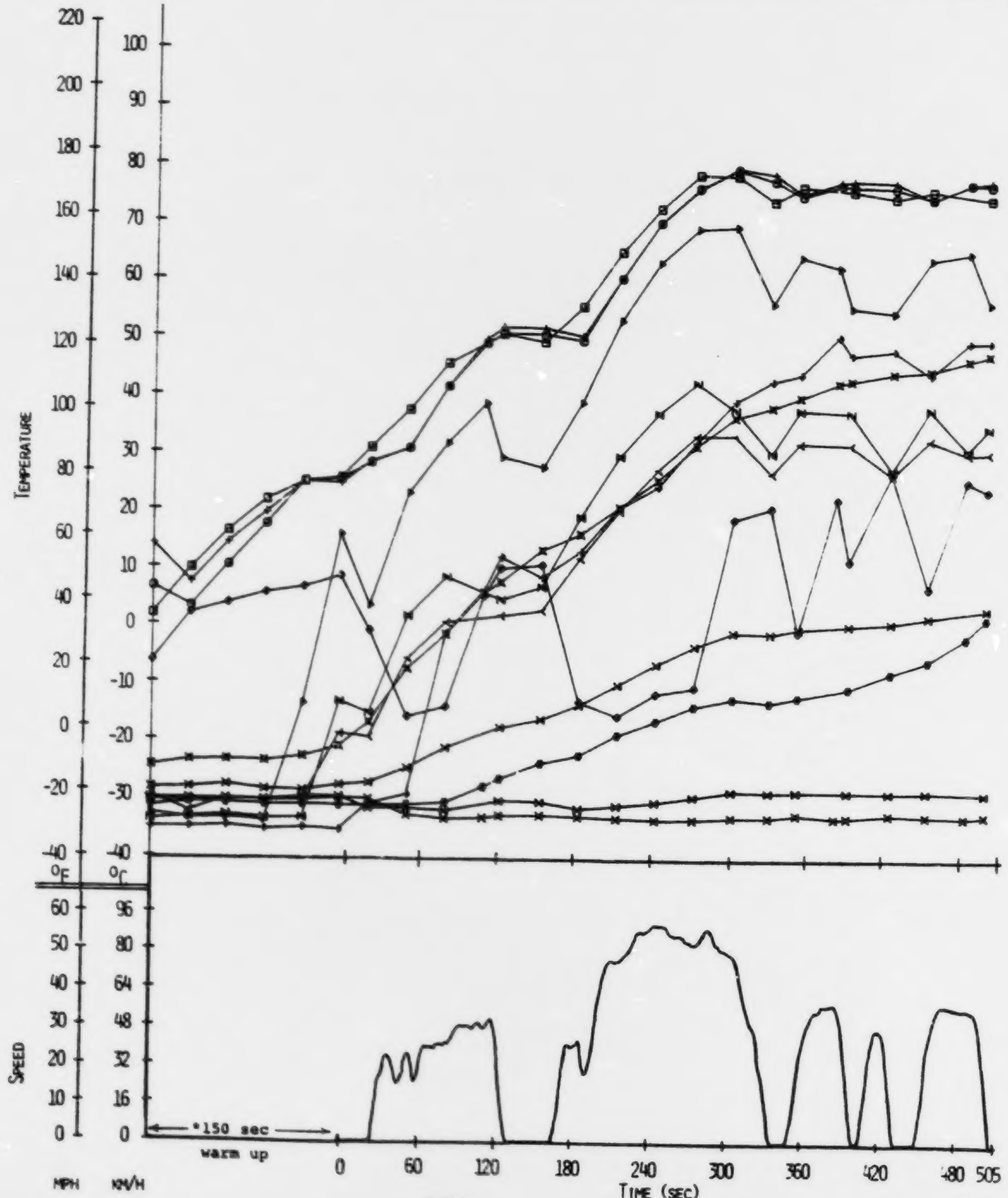


Figure 119

VEHICLE NO: 9 PROPANE TEST NO: 9.1.5-3 TEST TEMPERATURE: -35 C

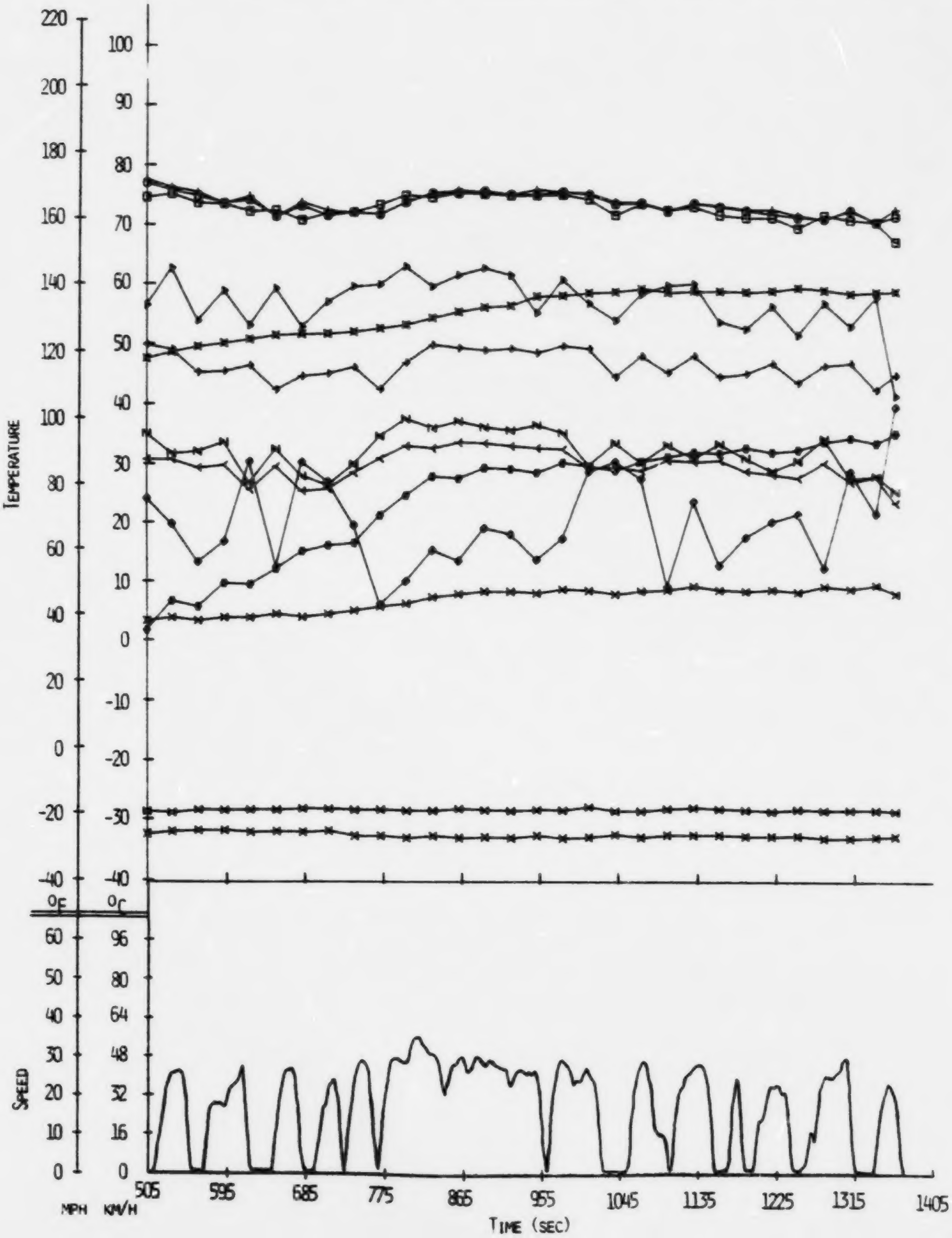
CITY CYCLE COLD STABILIZED
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 5 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
□ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
N — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
□ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 120**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.5-3 TEST TEMPERATURE: -35 C

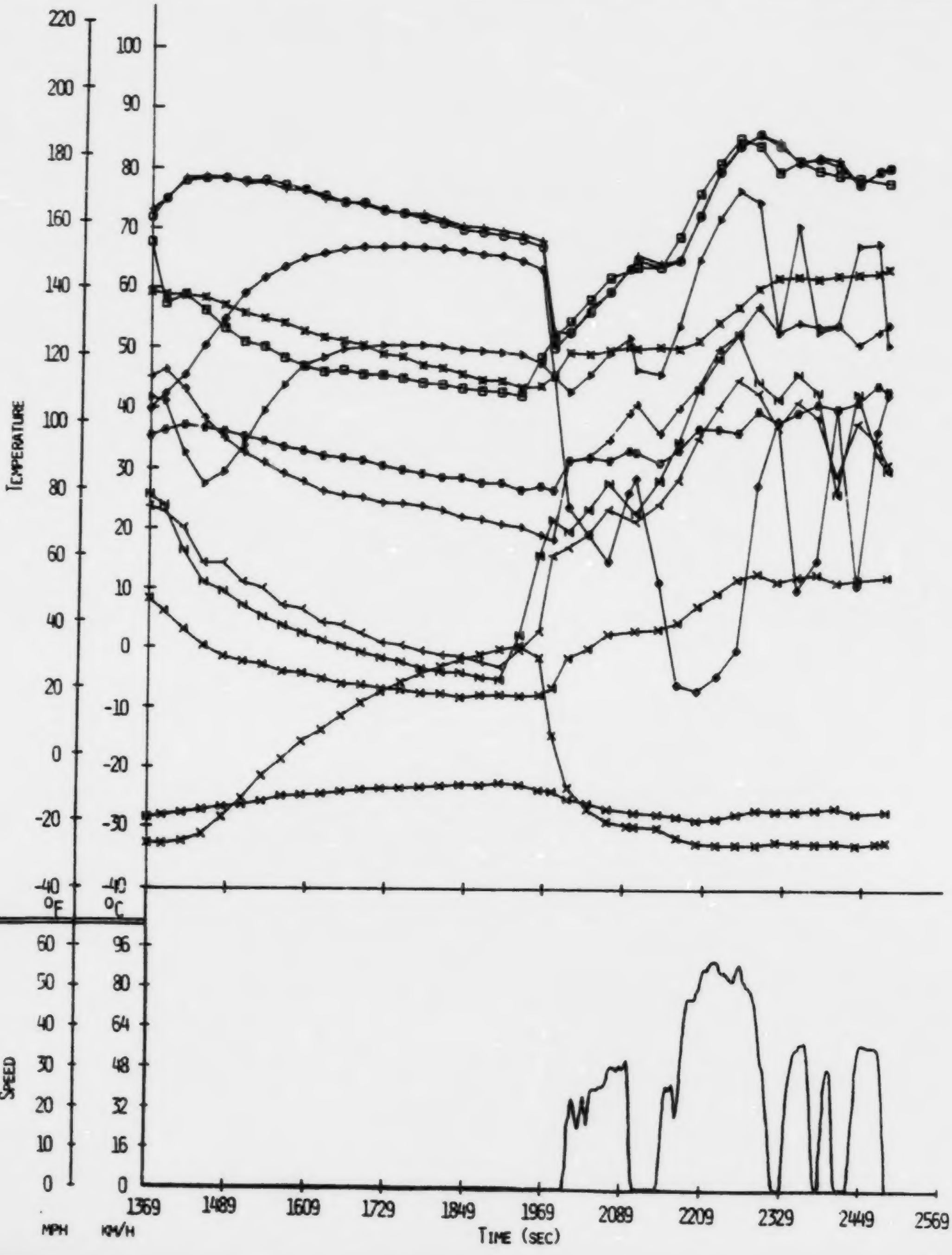
CITY CYCLE SOAK & HOT TRANSIENT
TEMPERATURE TRACE

HARDWARE CONFIGURATION A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 5 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
⊕ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
ℕ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊟ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II **Figure 121**

VEHICLE NO: 9 PROPANE TEST NO: 9.1.5-3 TEST TEMPERATURE: -35 C

HIGHWAY CYCLE
TEMPERATURE TRACE

HARDWARE CONFIGURATION: A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS
W / BLOCK HEATER ON 5 HOURS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
◆ — Coolant - Lower Rad. Hose
○ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◇ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out

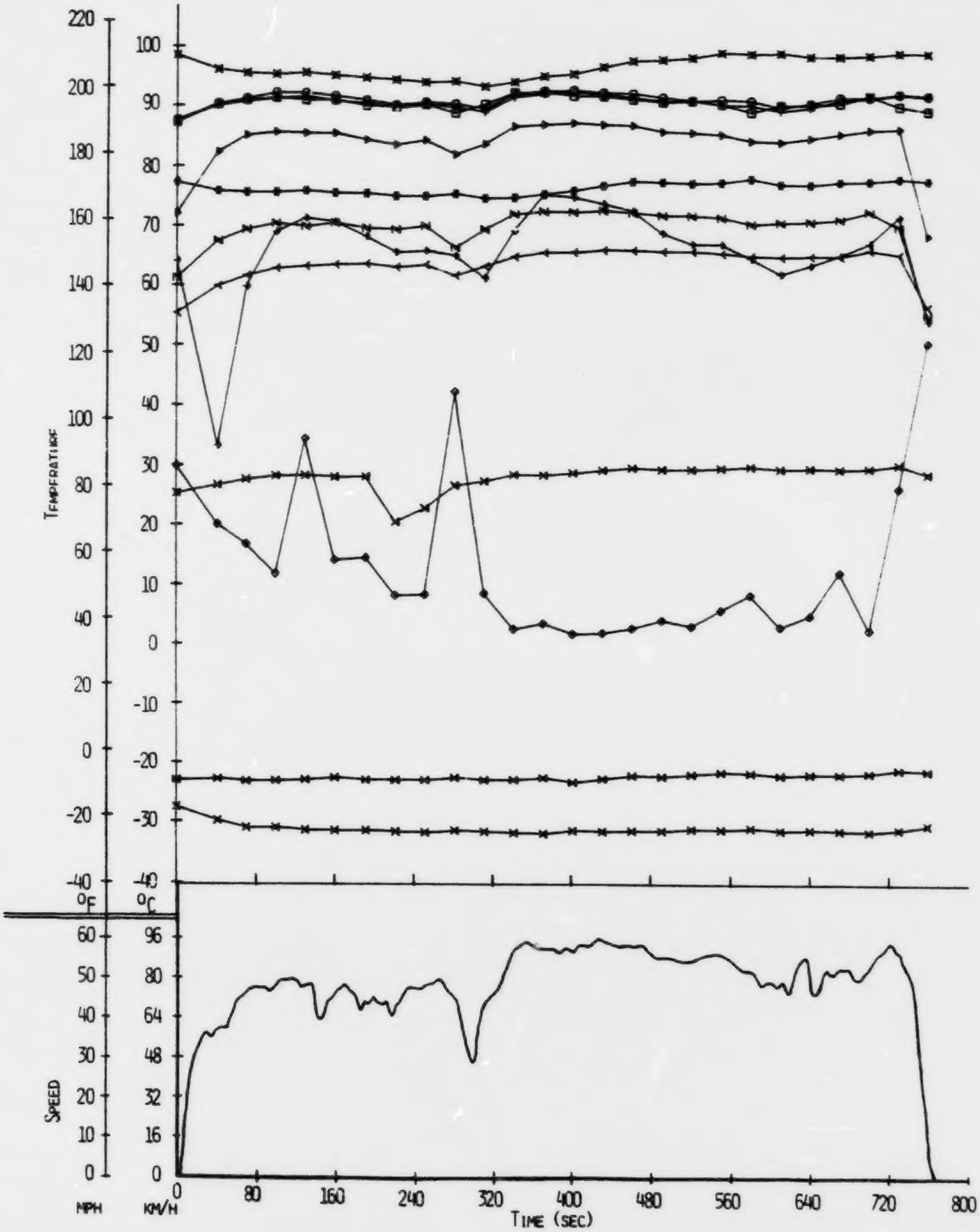


Figure 122

VEHICLE NO: 1 OPTIMUM COLD TIMING

CITY CYCLE COLD TRANSIENT
PARAMETER COMPARISON TRACE

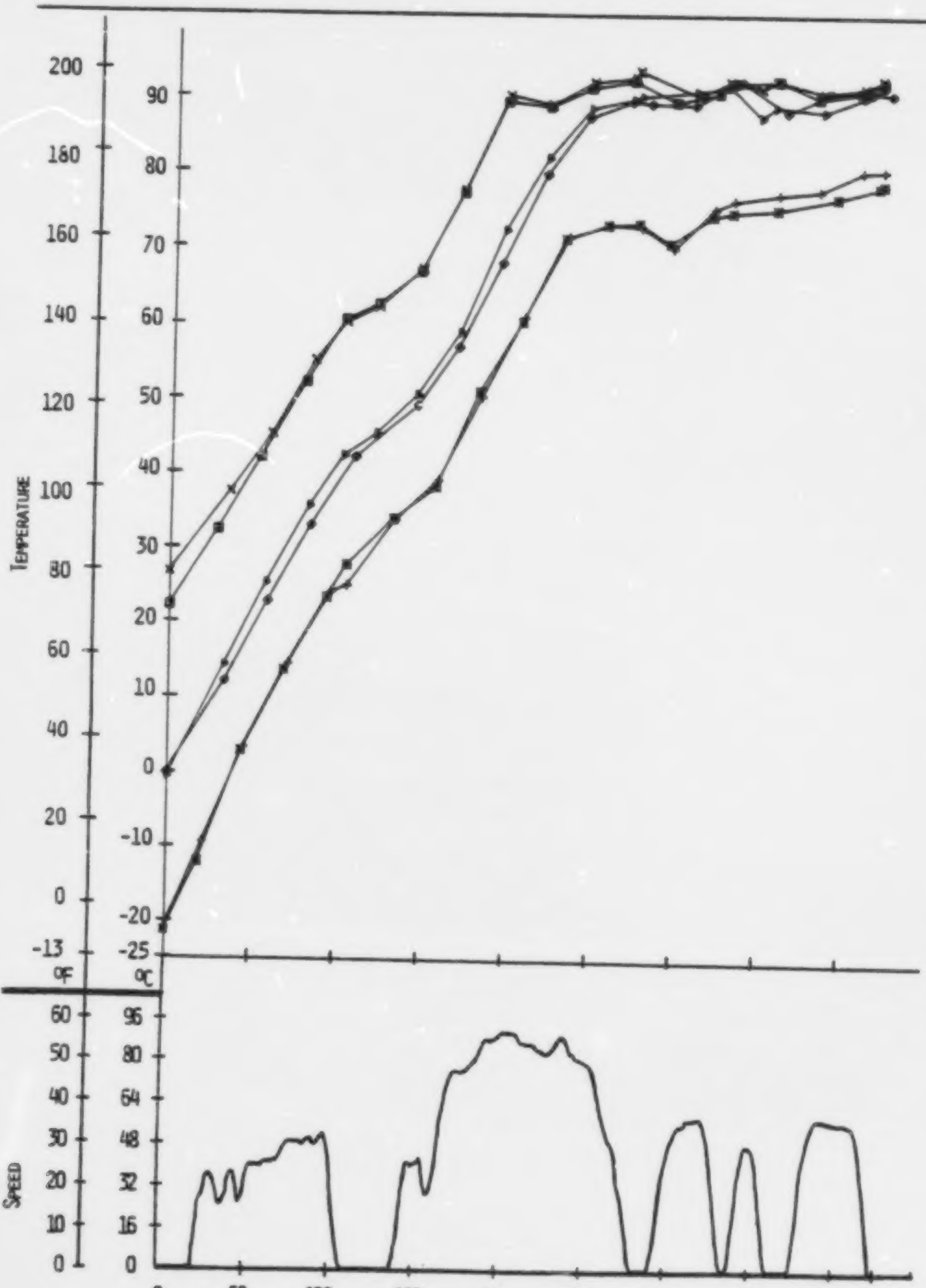
COOLANT THERMOSTAT TEMPERATURE VS. TIME

Base Vehicle: 1980 'L' Car with 9.5:1 Comp.
Ratio 1.7L Engine, 1980 EGR & 1979
Carburetion V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊟ — 1.1.2-3	25	Base
▷ — 1.1.3-2	0	"
+ — 1.1.4-8	-20	"
× — 1.2.2-2	25	Optimum Cold Timing
◇ — 1.2.3-3	0	"
✳ — 1.2.4-9	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 123

VEHICLE NO: 1 OPTIMUM COLD TIMING

CITY CYCLE COLD STABILIZED
PARAMETER COMPARISON TRACE

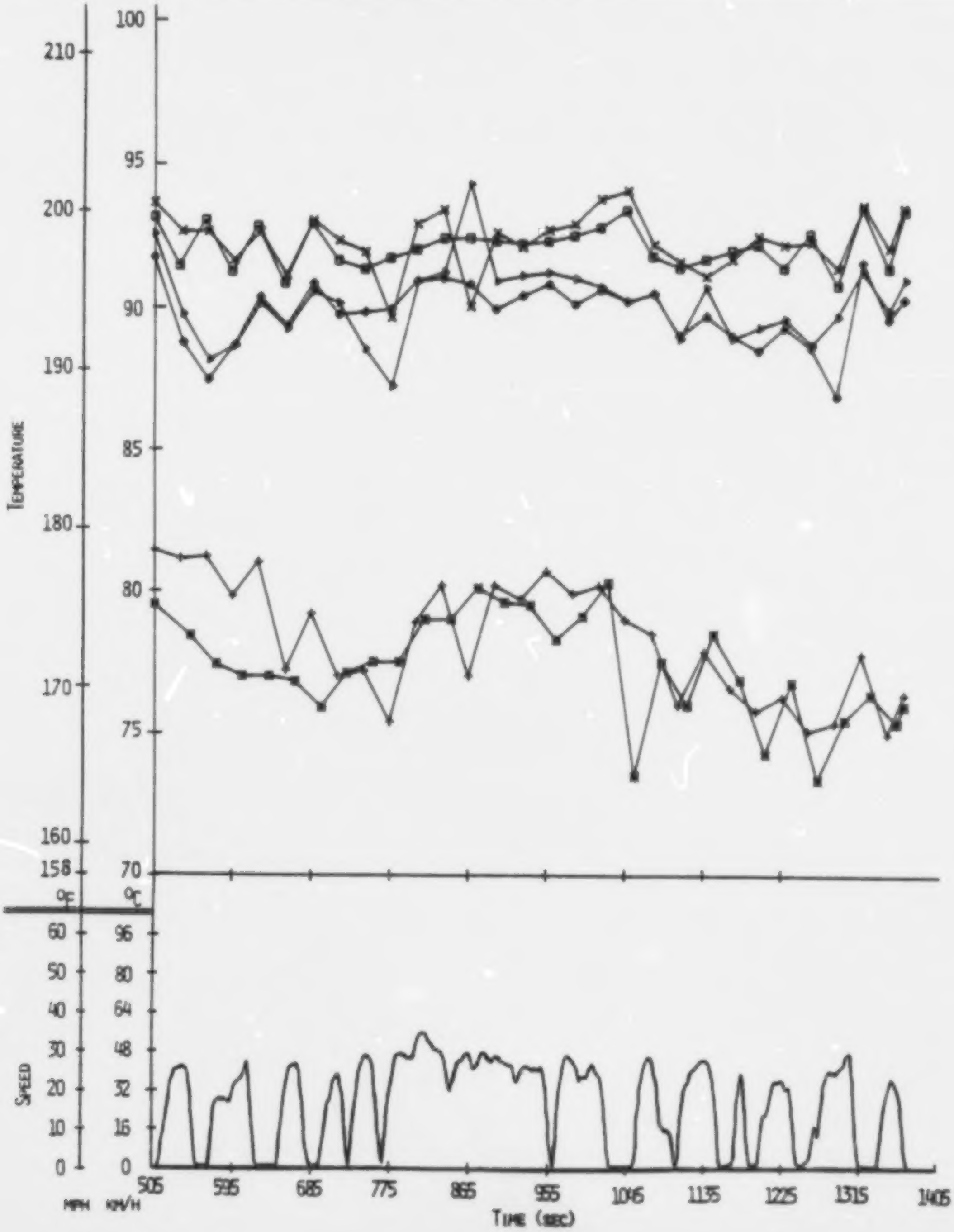
COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 9.5:1 Comp.
Ratio 1.7L Engine, 1980 EGR & 1979
Carburetion V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 1.1.2-3	25	Base
▷ — 1.1.3-2	0	"
+ — 1.1.4-8	-20	"
× — 1.2.2-2	25	Optimum Cold Timing
◇ — 1.2.3-3	0	"
✳ — 1.2.4-9	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 124

VEHICLE NO: 1 OPTIMUM COLD TIMING

CITY CYCLE SOAK & HOT TRANSIENT
PARAMETER COMPARISON TRACE

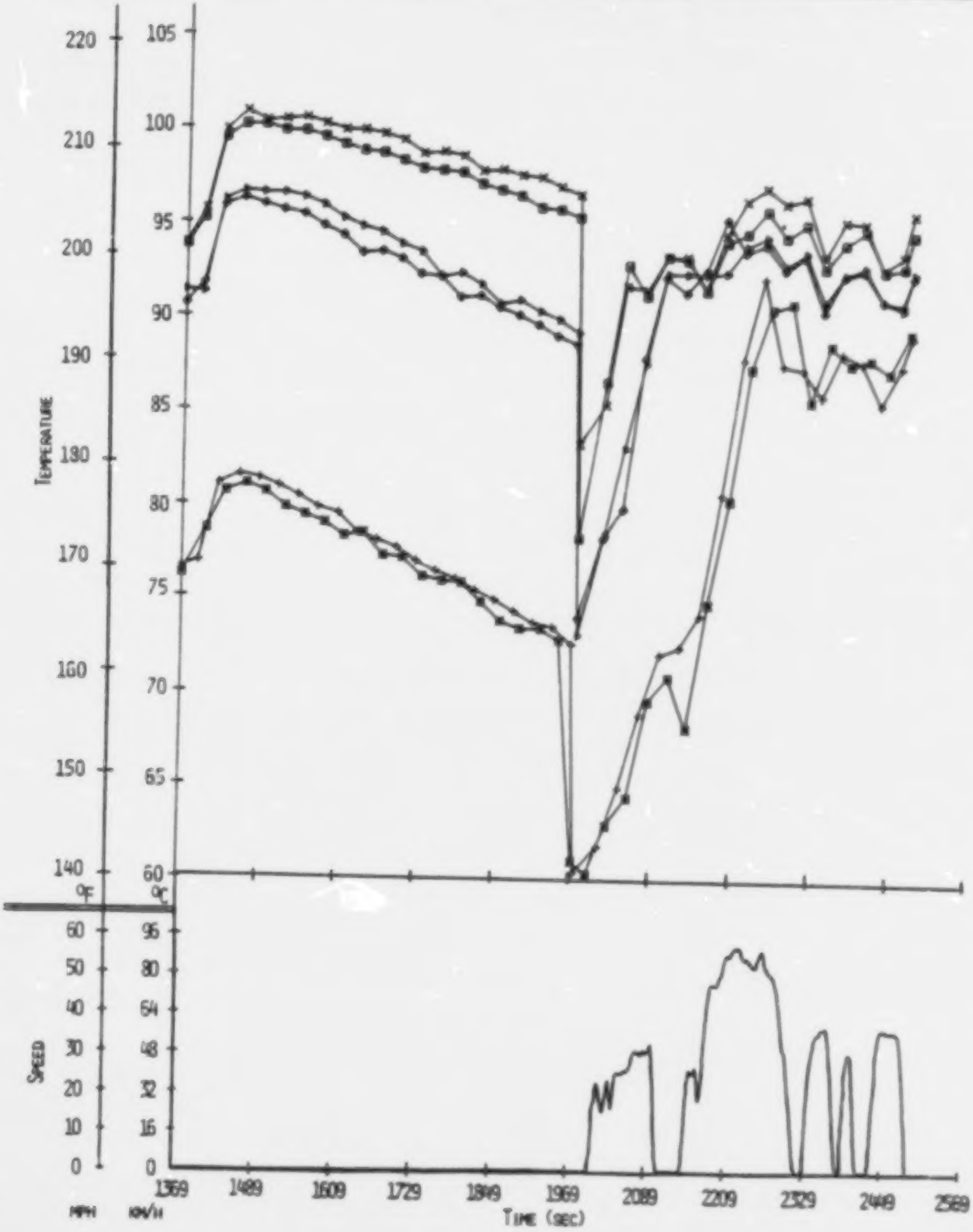
COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 9.5:1 Comp.
Ratio 1.7L Engine, 1980 EGR & 1979
Carburetion V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
□ — 1.1.2-3	25	Base
[• — 1.1.3-2	0	"
+ — 1.1.4-8	-20	"
× — 1.2.2-2	25	Optimum Cold Timing
◇ — 1.2.3-3	0	"
▣ — 1.2.4-9	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 125

VEHICLE NO: 1 OPTIMUM COLD TIMING

HIGHWAY CYCLE
PARAMETER COMPARISON TRACE

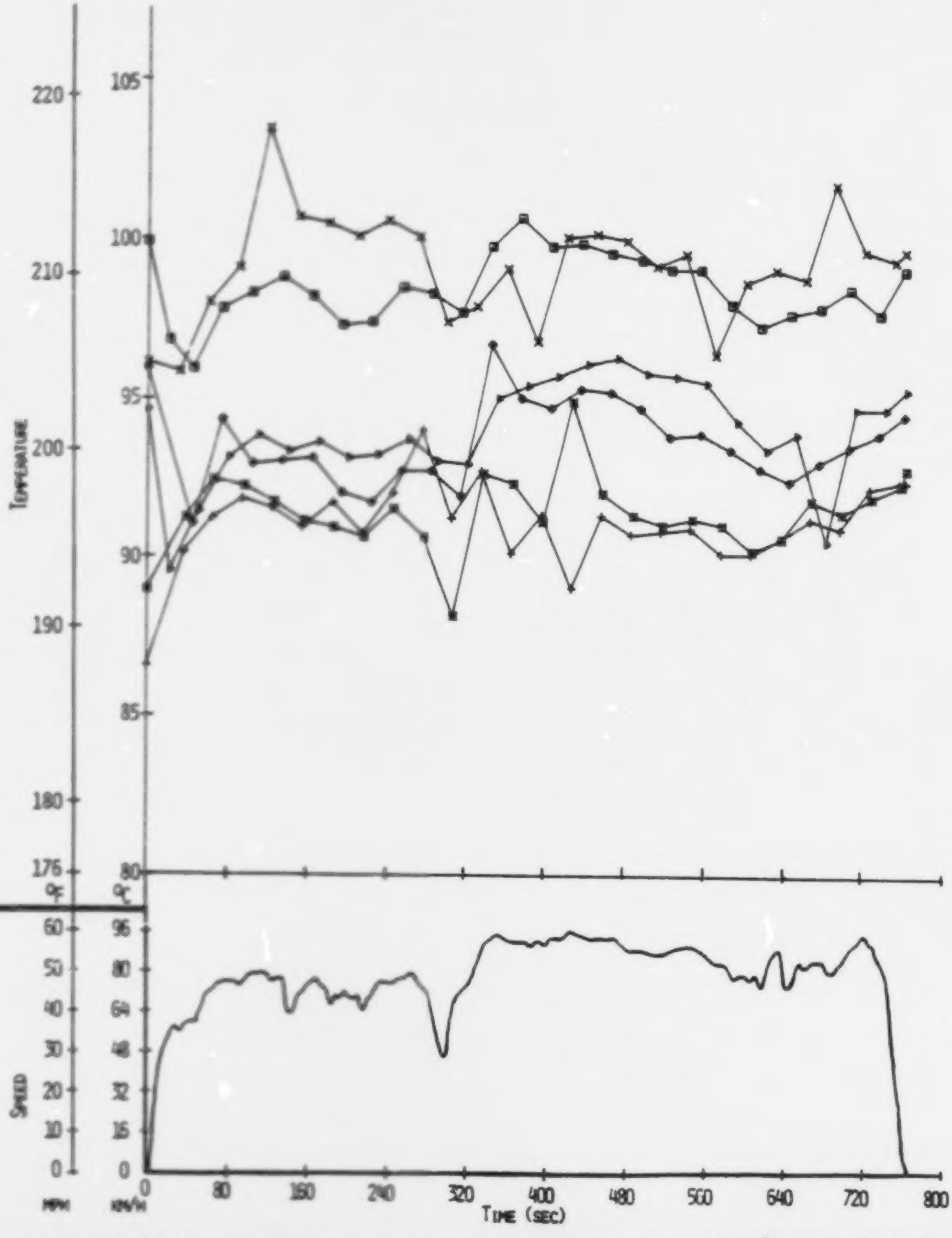
COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 9.5:1 Comp.
Ratio 1.7L Engine, 1980 EGR & 1979
Carburetion V.I.N.# 109222

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊟ — 1.1.2-3	25	Base
▷ — 1.1.3-2	0	"
+ — 1.1.4-8	-20	"
× — 1.2.2-2	25	Optimum Cold Timing
◇ — 1.2.3-3	0	"
✱ — 1.2.4-9	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 126

VEHICLE NO: 3 AUTOMATIC IDLE SPEED

CITY CYCLE COLD TRANSIENT
PARAMETER COMPARISON TRACE

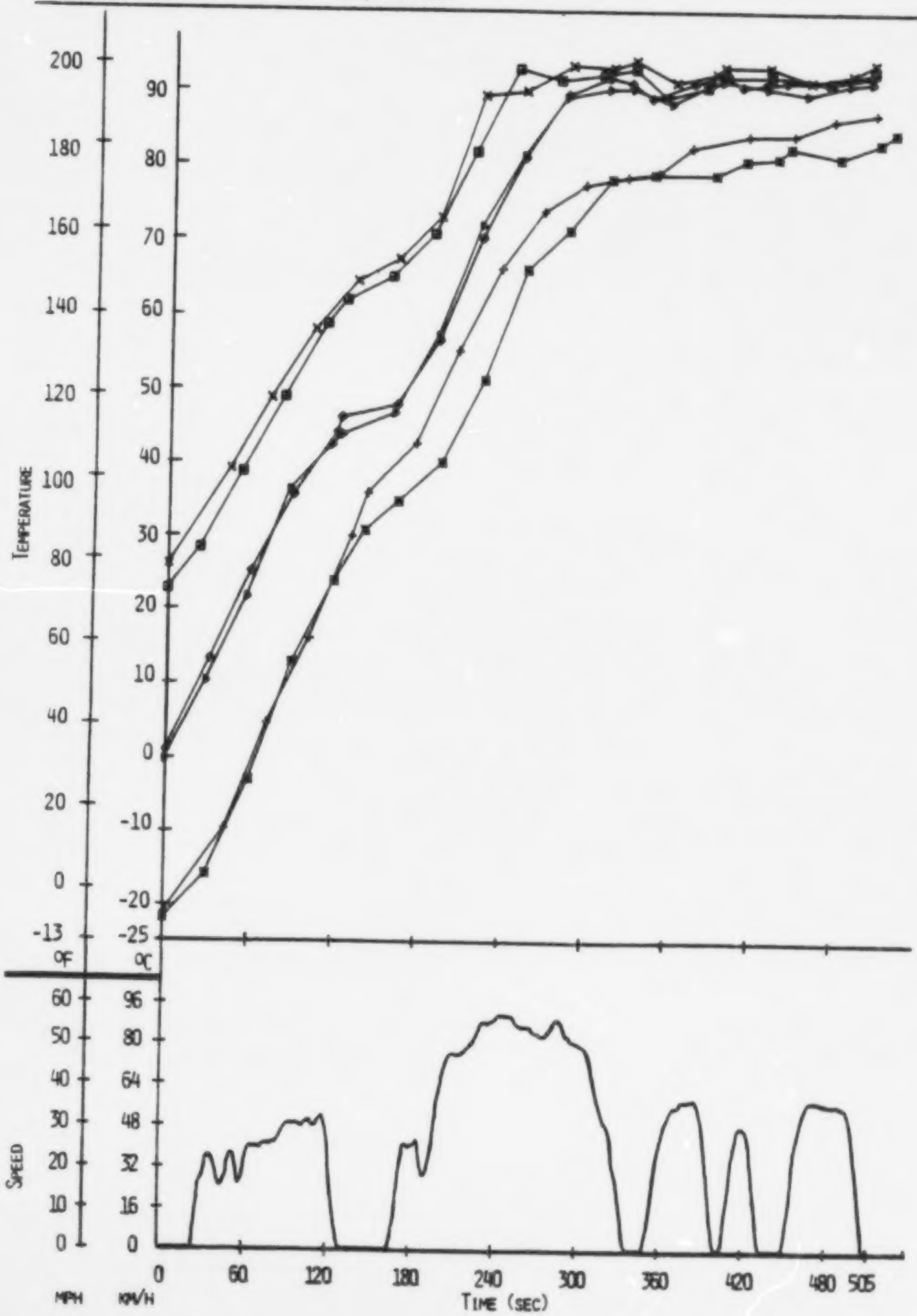
COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing
V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 3.1.2-3	25	Base
▷ — 3.1.3-3	0	"
+ — 3.1.4-1	-20	"
× — 3.2.2-2	25	Automatic Idle Speed
◇ — 3.2.3-1	0	"
✳ — 3.2.4-2	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II Figure 127

VEHICLE NO: 3 AUTOMATIC IDLE SPEED

CITY CYCLE COLD STABILIZED
PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 8.2:1 Comp.
Ratio 1.7L Engine,

1979 Carb. EGR & Spark Timing
V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 3.1.2-3	25	Base
▷ — 3.1.3-3	0	"
+ — 3.1.4-1	-20	"
× — 3.2.2-2	25	Automatic Idle Speed
◇ — 3.2.3-1	0	"
✱ — 3.2.4-2	-20	"

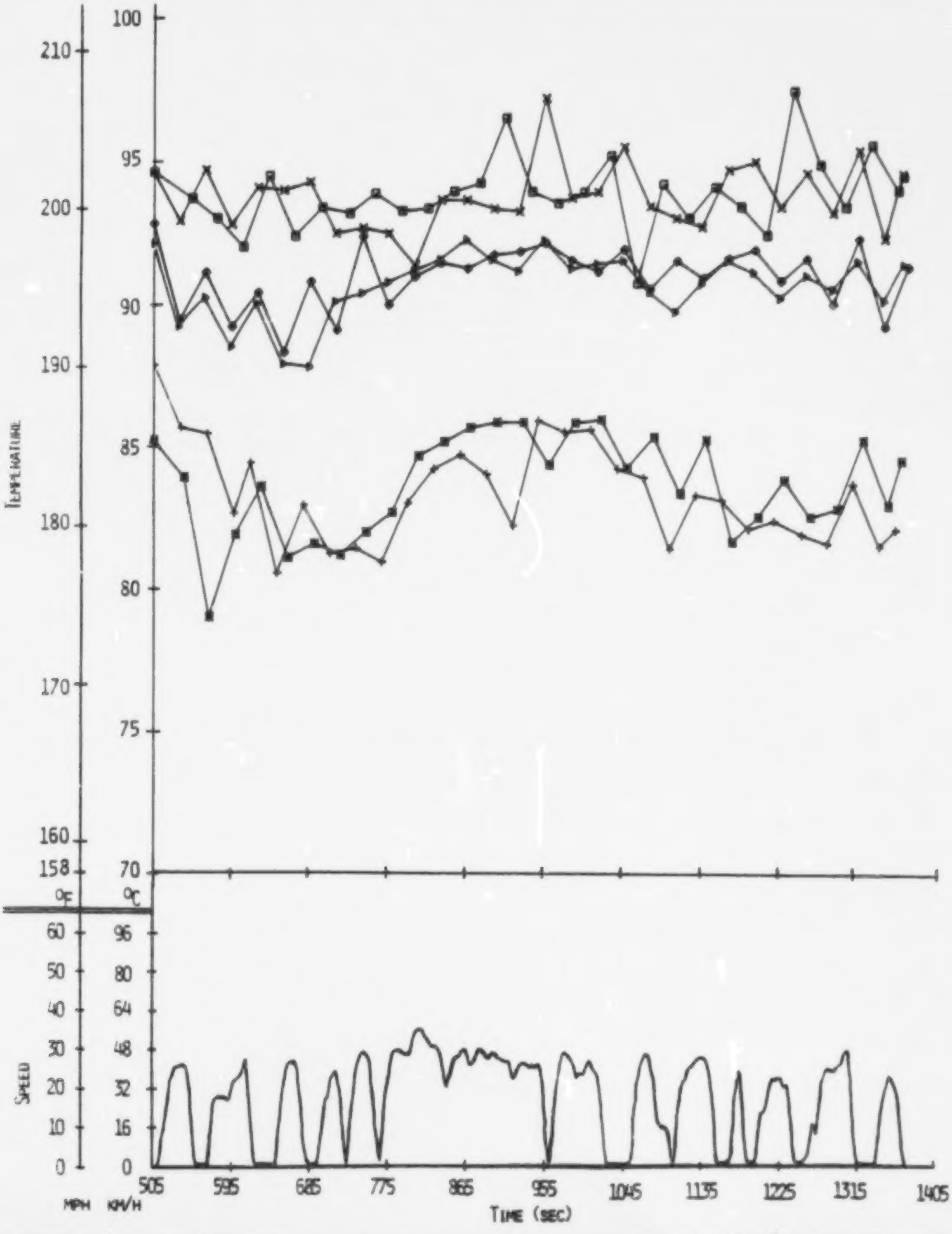


Figure 128

VEHICLE NO: 3 AUTOMATIC IDLE SPEED

CITY CYCLE SOAK & HOT TRANSIENT
PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

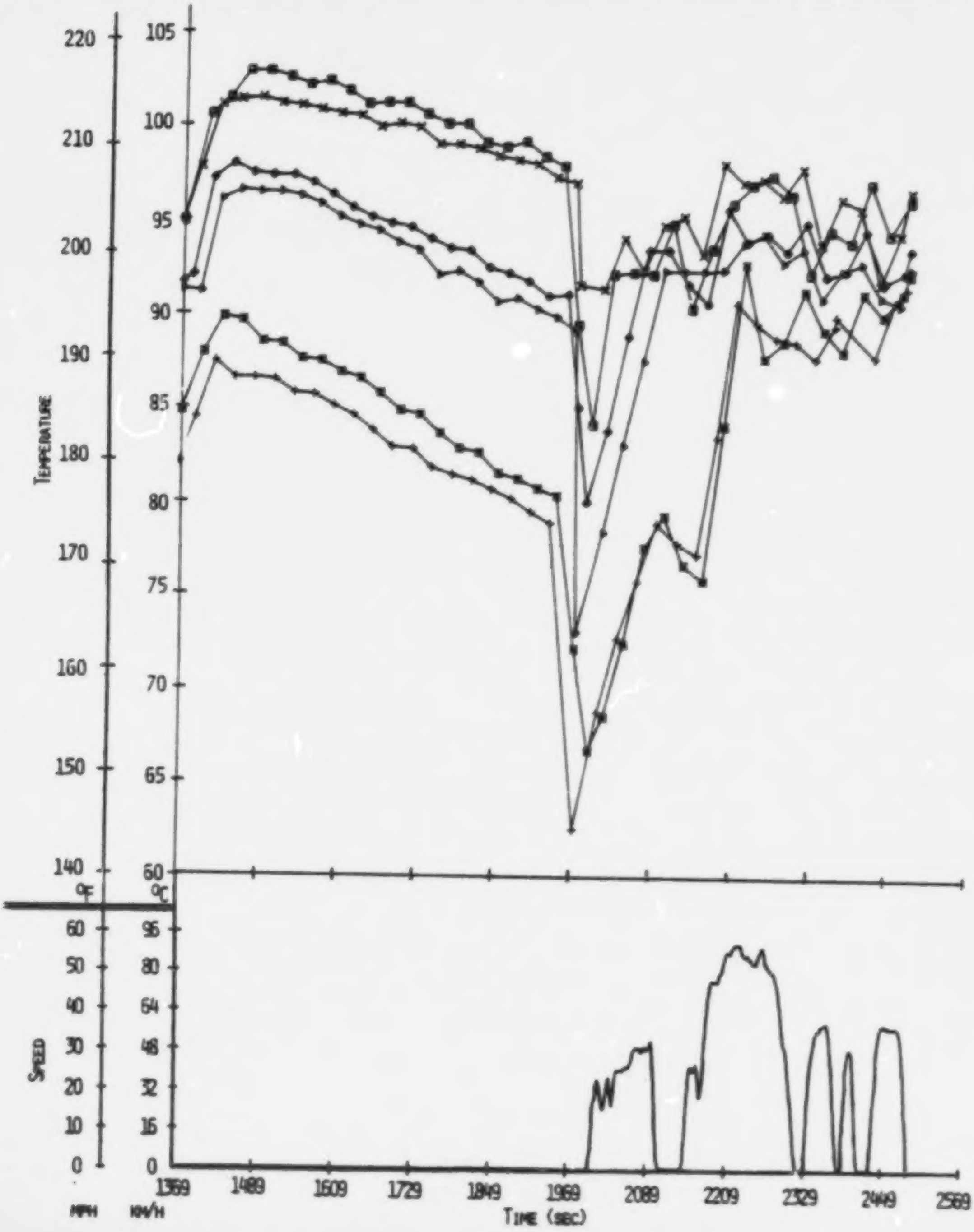
Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,

1979 Carb. EGR & Spark Timing
V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 3.1.2-3	25	Base
▷ — 3.1.3-3	0	"
+ — 3.1.4-1	-20	"
× — 3.2.2-2	25	Automatic Idle Speed
◇ — 3.2.3-1	0	"
✱ — 3.2.4-2	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 129

VEHICLE NO: 3 AUTOMATIC IDLE SPEED

HIGHWAY CYCLE
PARAMETER COMPARISON TRACE

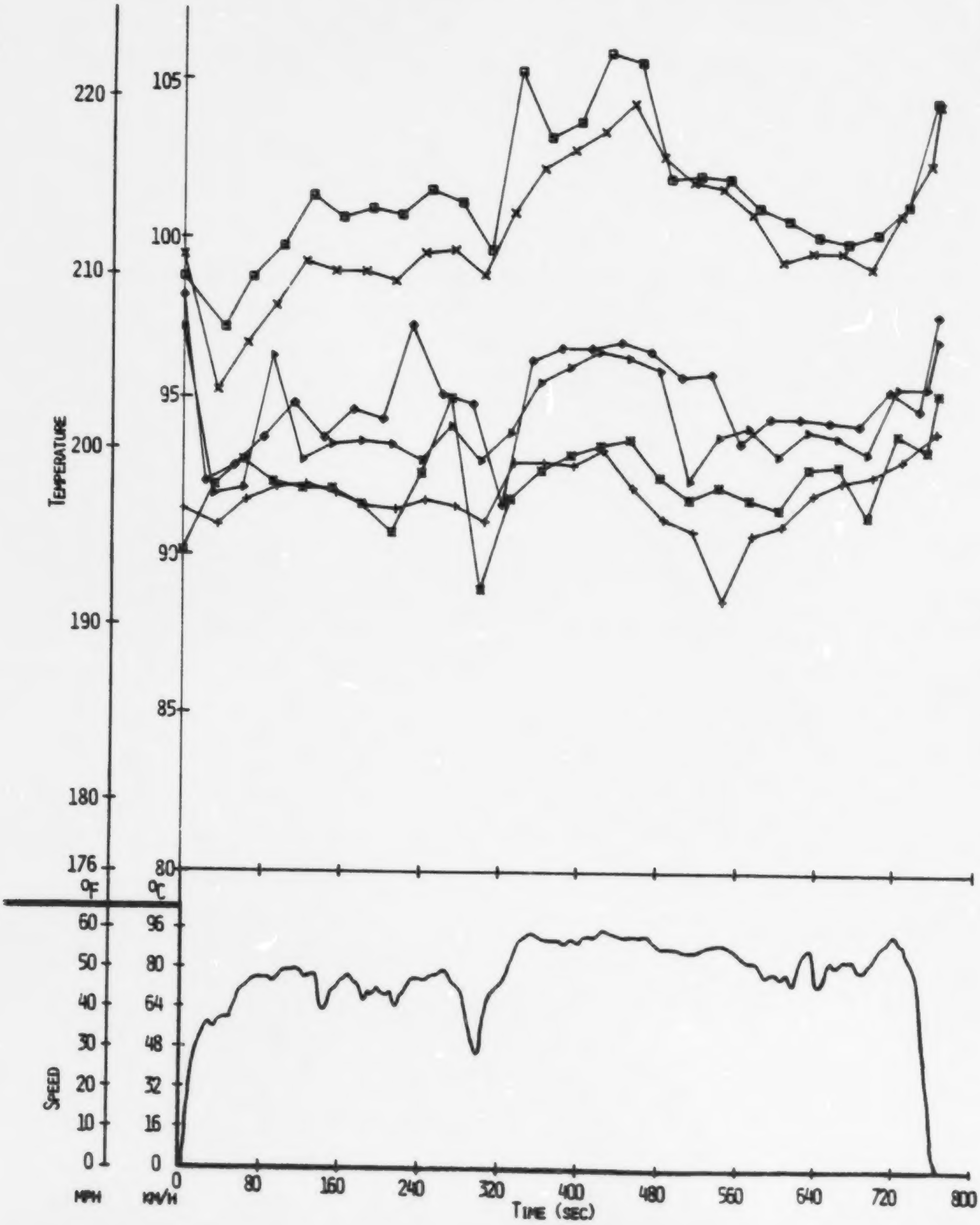
COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with 8.2:1 Comp. Ratio 1.7L Engine,
1979 Carb. EGR & Spark Timing
V.I.N.# 117590

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

Test #	Test Temp. °C	Hardware Config.
⊡ — 3.1.2-3	25	Base
▷ — 3.1.3-3	0	"
+ — 3.1.4-1	-20	"
× — 3.2.2-2	25	Automatic Idle Speed
◇ — 3.2.3-1	0	"
✱ — 3.2.4-2	-20	"



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 130

VEHICLE No: 9 PROPANE

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
□ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
< — 9.1.4B-1	-20	A - with 2 hr block heat preheat
⋈ — 9.1.5-3	-35	A[2]- with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✳ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.

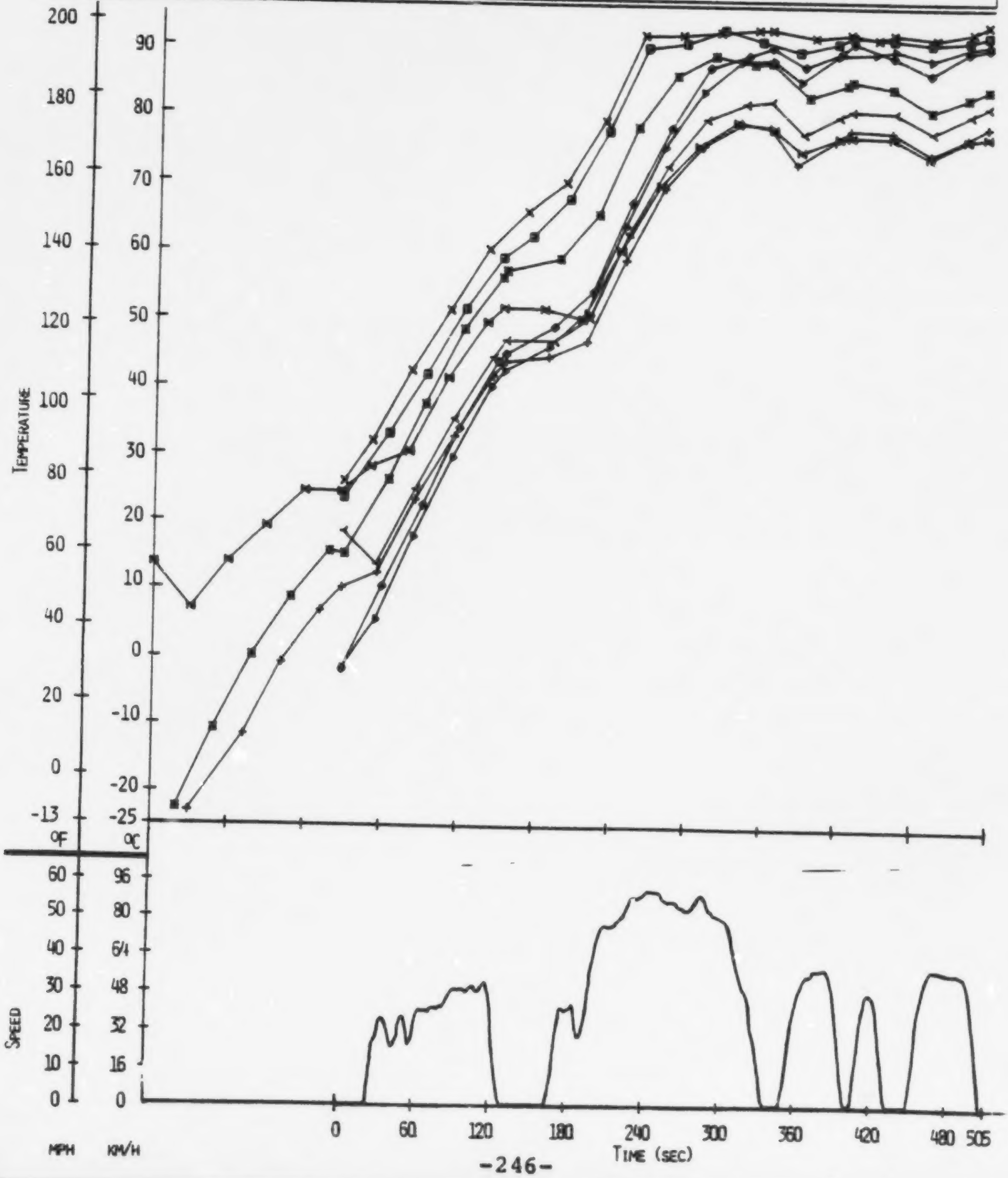


Figure 131

VEHICLE NO: 9 PROPANE

CITY CYCLE COLD STABILIZED
PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

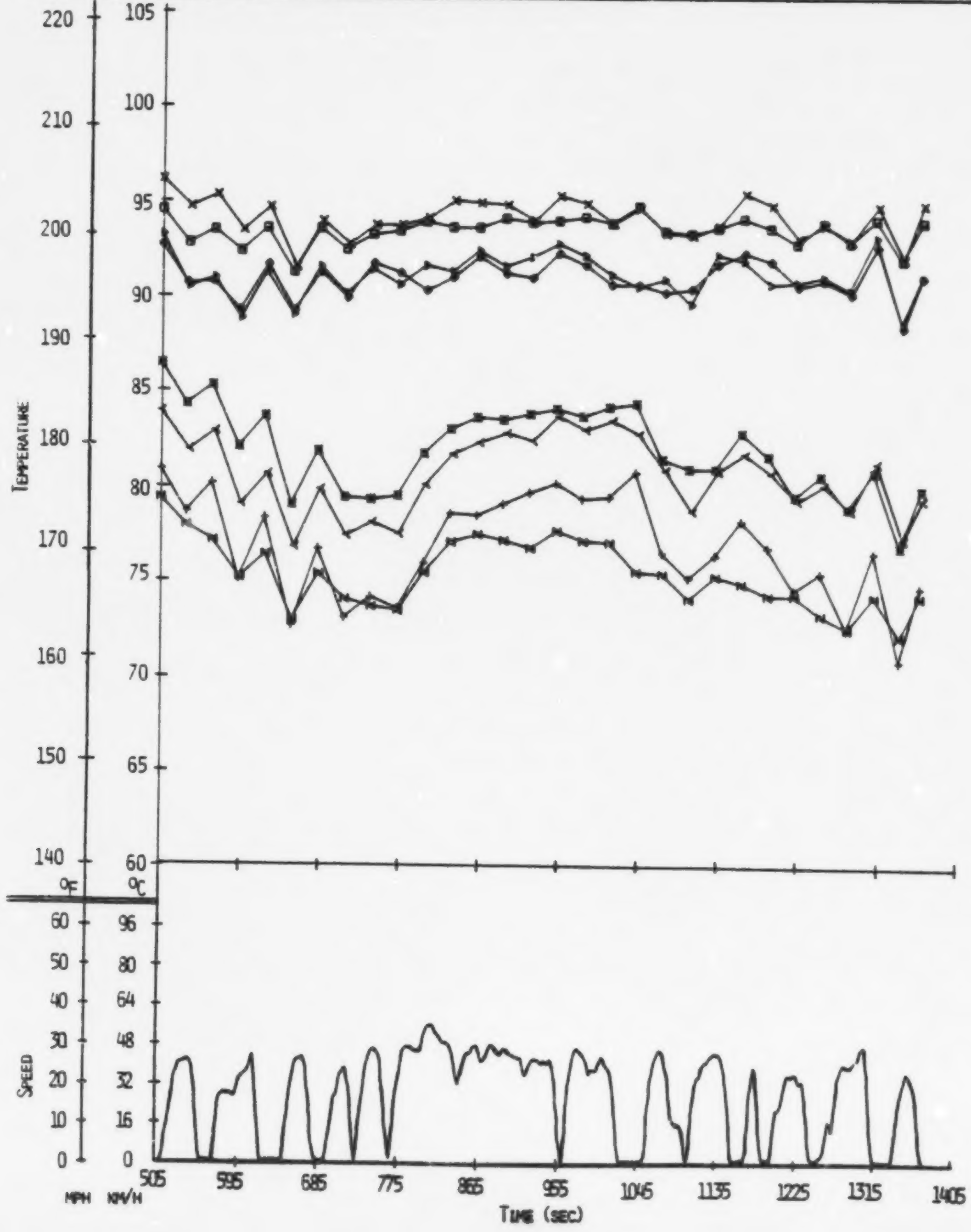
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
< — 9.1.4B-1	-20	A - with 2 hr block heat preheat
N — 9.1.5-3	-35	A[2]- with 5 hr block heat preheat
X — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✳ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 132

VEHICLE NO: 9 PROPANE

CITY CYCLE SOAK & HOT TRANSIENT
PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

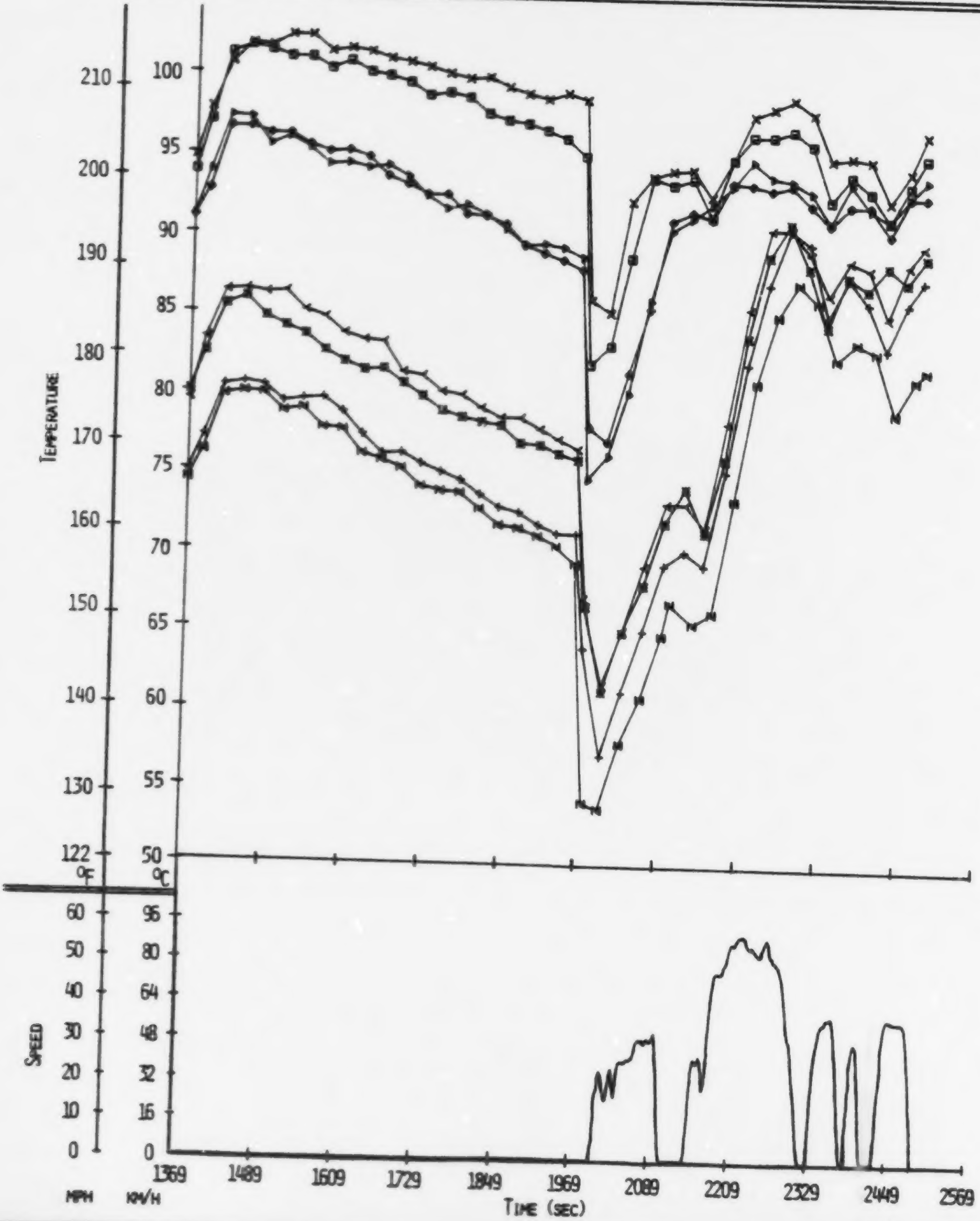
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
< — 9.1.4B-1	-20	A - with 2 hr block heat preheat
N — 9.1.5-3	-35	A[2] - with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✳ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 133

VEHICLE NO: 9 PROPANE

HIGHWAY CYCLE
PARAMETER COMPARISON TRACE

COOLANT THERMOSTAT TEMPERATURE
VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

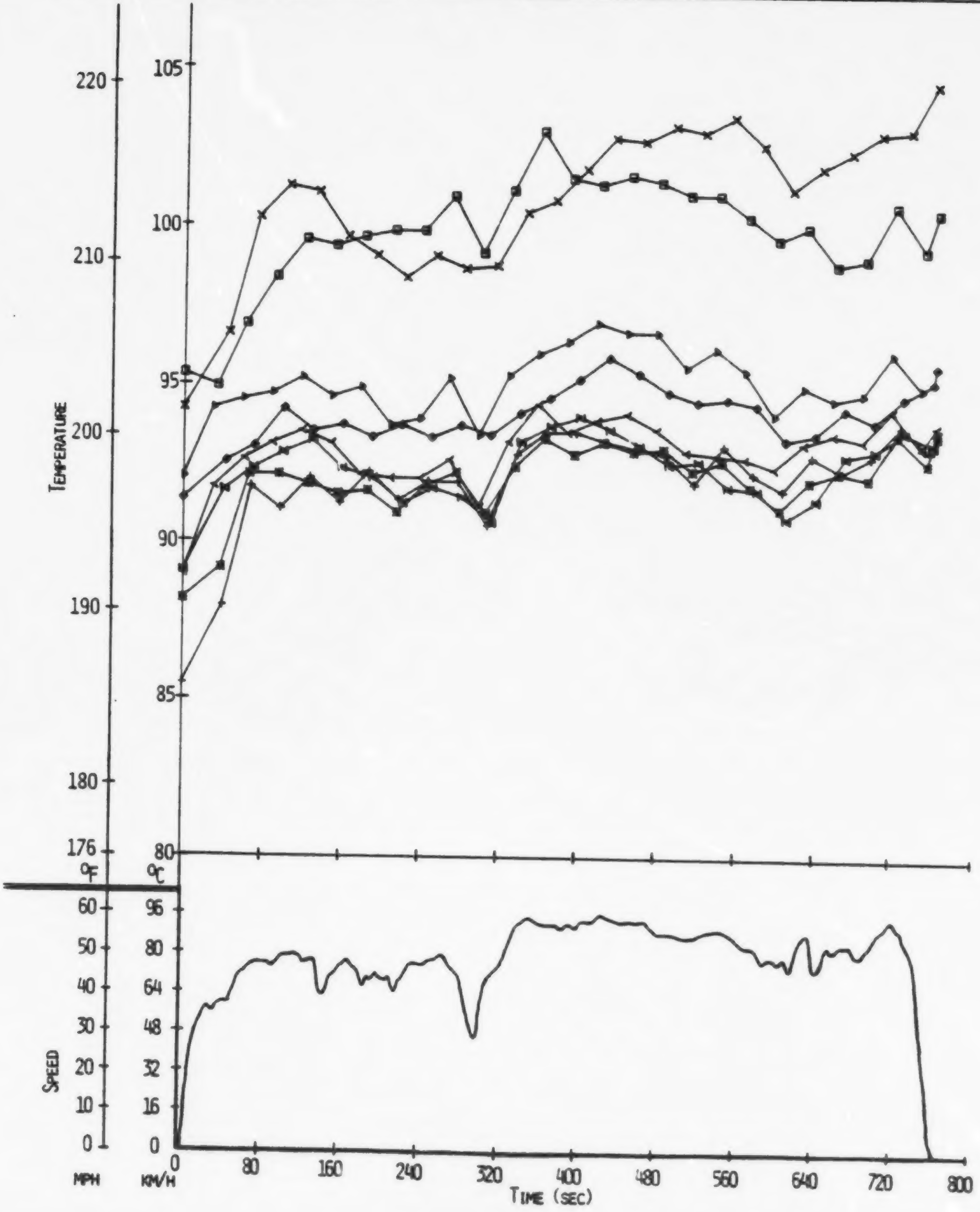
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
< — 9.1.4B-1	-20	A - with 2 hr block heat preheat
N — 9.1.5-3	-35	A[2] - with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✳ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 134

VEHICLE NO: 9 PROPANE

CITY CYCLE COLD TRANSIENT PARAMETER COMPARISON TRACE

COOLANT VAPOURIZER OUT VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

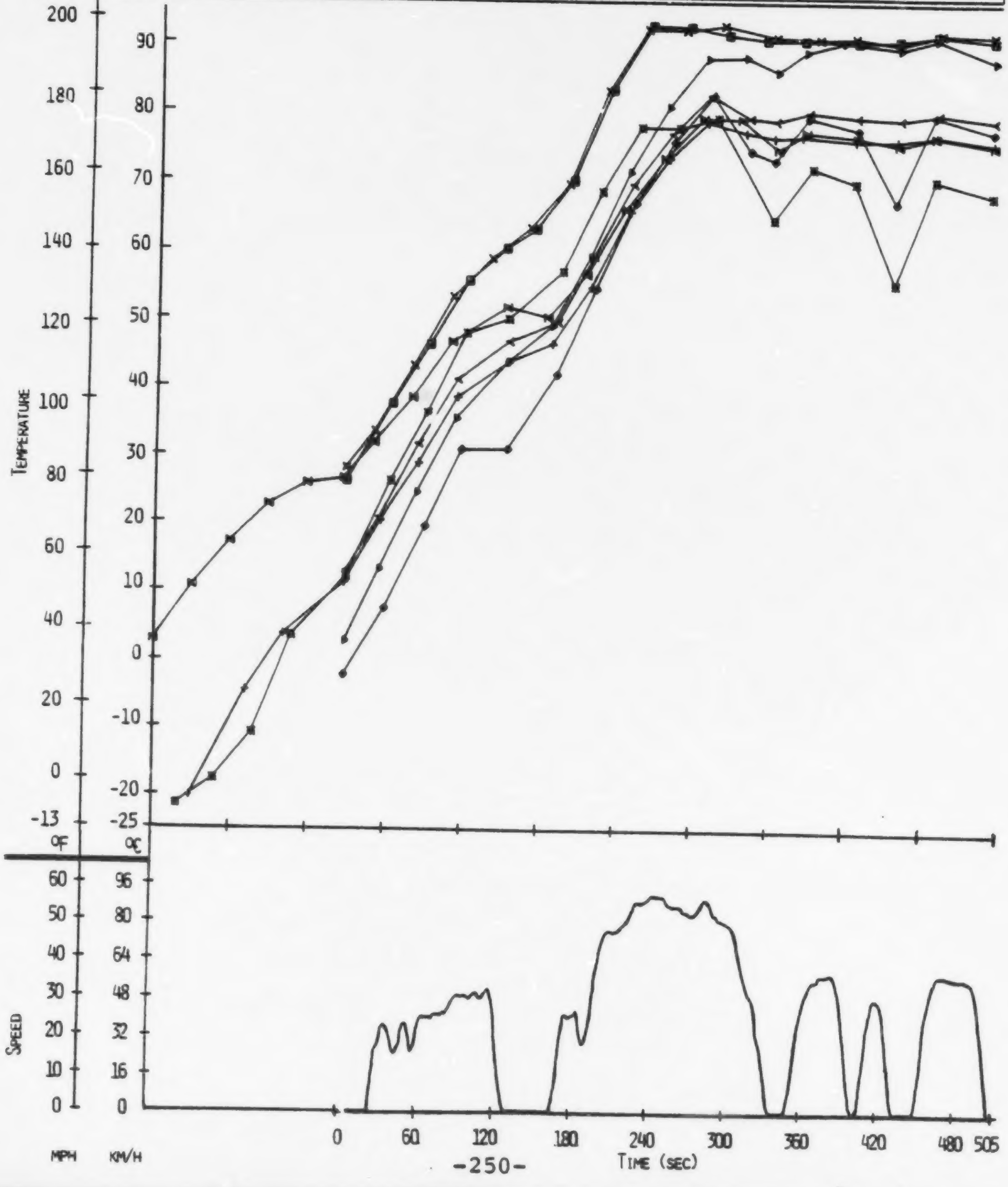
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊟ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
< — 9.1.4B-1	-20	A - with 2 hr block heat preheat
N — 9.1.5-3	-35	A[2] - with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✱ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 135

VEHICLE NO: 9 PROPANE

CITY CYCLE COLD STABILIZED
PARAMETER COMPARISON TRACE

COOLANT VAPOURIZER OUT
VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

Propane Carburetion
V.I.N.# 118220

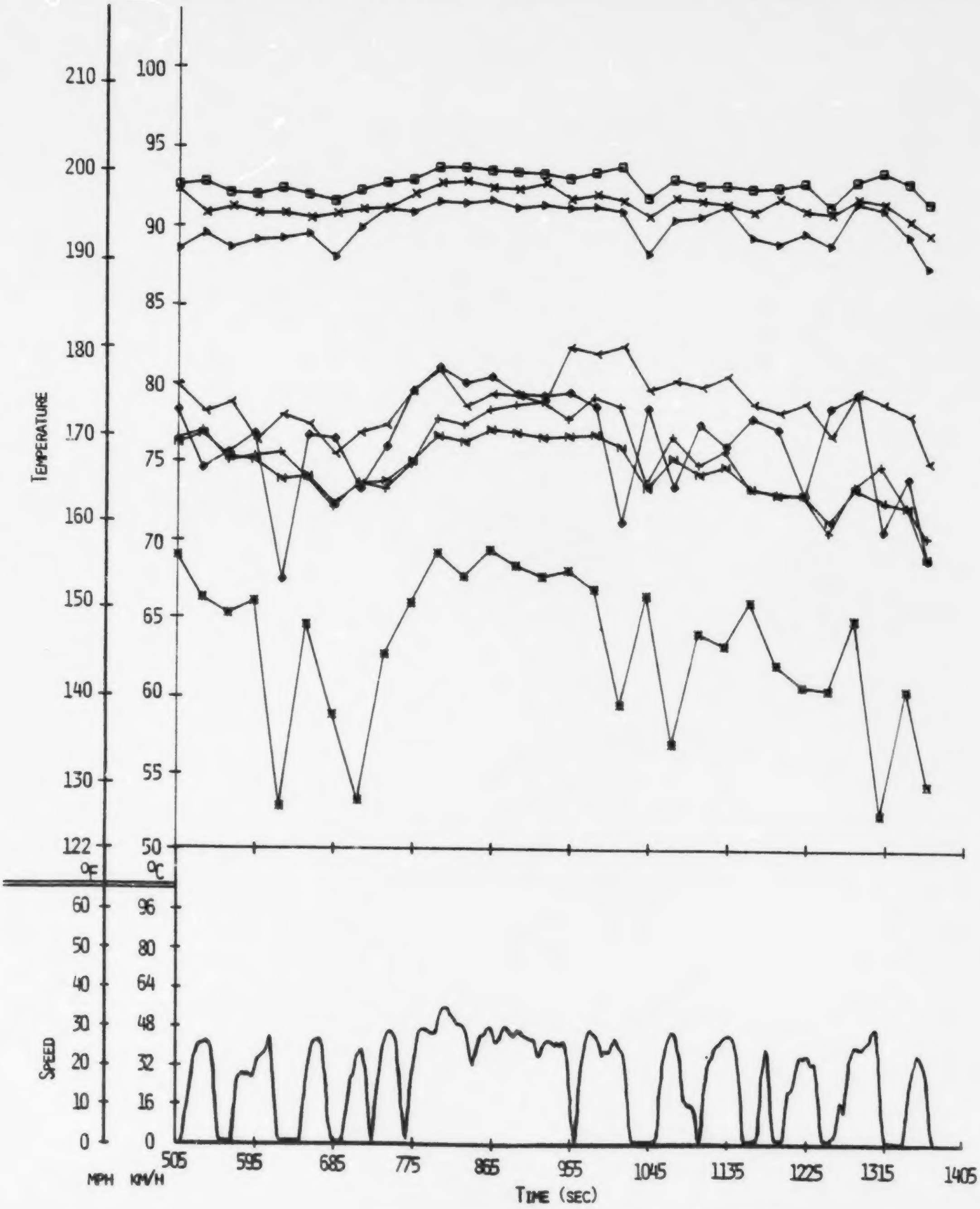
Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A^1
≺ — 9.1.4B-1	-20	A - with 2 hr block heat preheat
⋈ — 9.1.5-3	-35	A^2- with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✳ — 9.2.4-1	-20	B^3

Notes:

1. **Additional 120 sec idle period performed prior to start of test cycle.**
2. **Additional 150 sec idle period performed prior to start of test cycle.**
3. **Additional 130 sec idle period performed prior to start of test cycle.**



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 136

VEHICLE NO: 9 PROPANE

CITY CYCLE SOAK & HOT TRANSIENT
PARAMETER COMPARISON TRACE

COOLANT VAPOURIZER OUT
VERSUS TIME

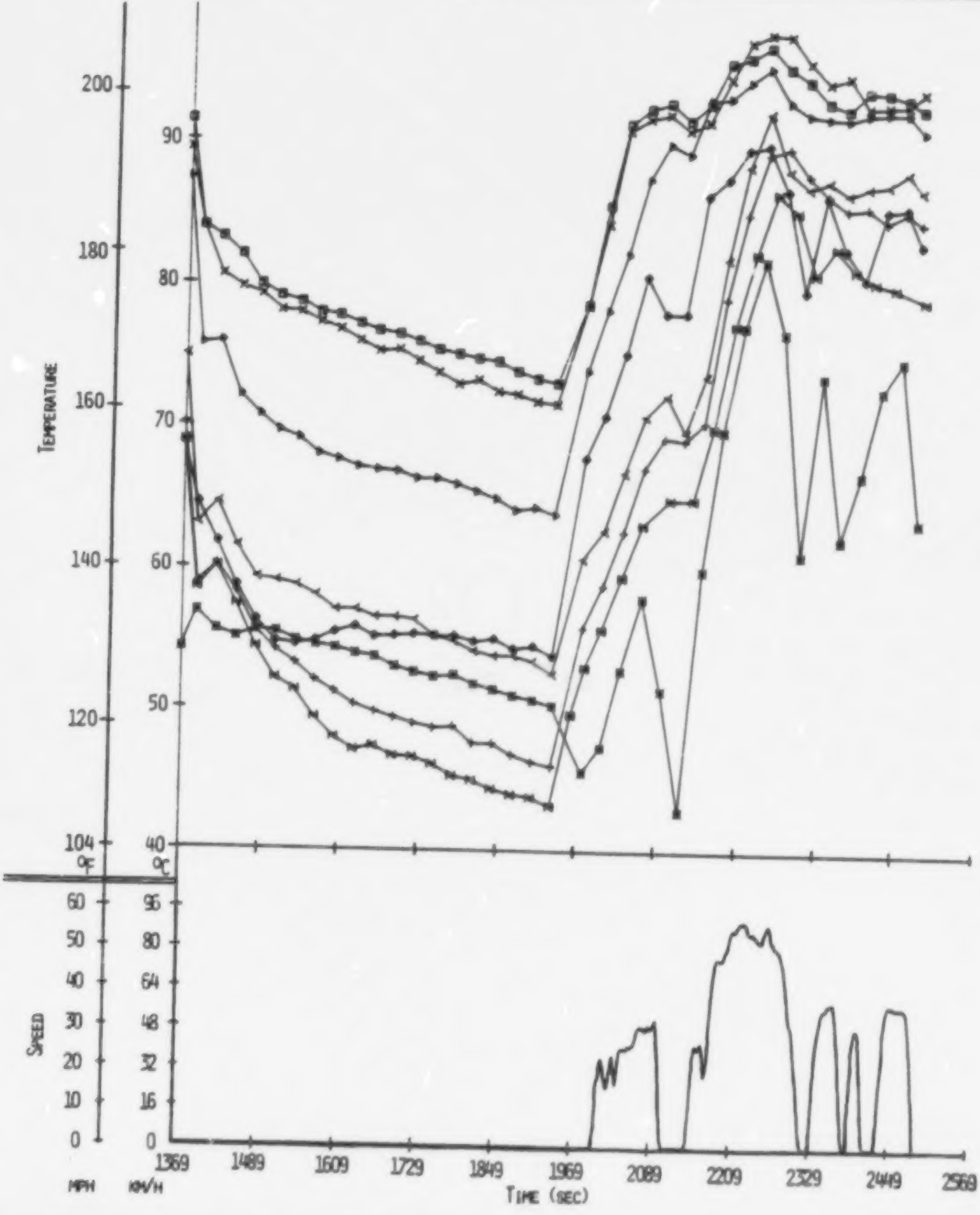
Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ — 9.1.2-2	25	A
▷ — 9.1.3-1	0	A
+ — 9.1.4-1	-20	A[1]
≺ — 9.1.4B-1	-20	A - with 2 hr block heat preheat
⋈ — 9.1.5-3	-35	A[2] - with 5 hr block heat preheat
× — 9.2.2-1	25	B
◇ — 9.2.3-1	0	B
✱ — 9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 137

VEHICLE NO: 9 PROPANE

HIGHWAY CYCLE
PARAMETER COMPARISON TRACE

COOLANT VAPOURIZER OUT
VERSUS TIME

Base Vehicle: 1980 'L' Car with
9.3:1 Comp. Ratio
1.7L Engine,

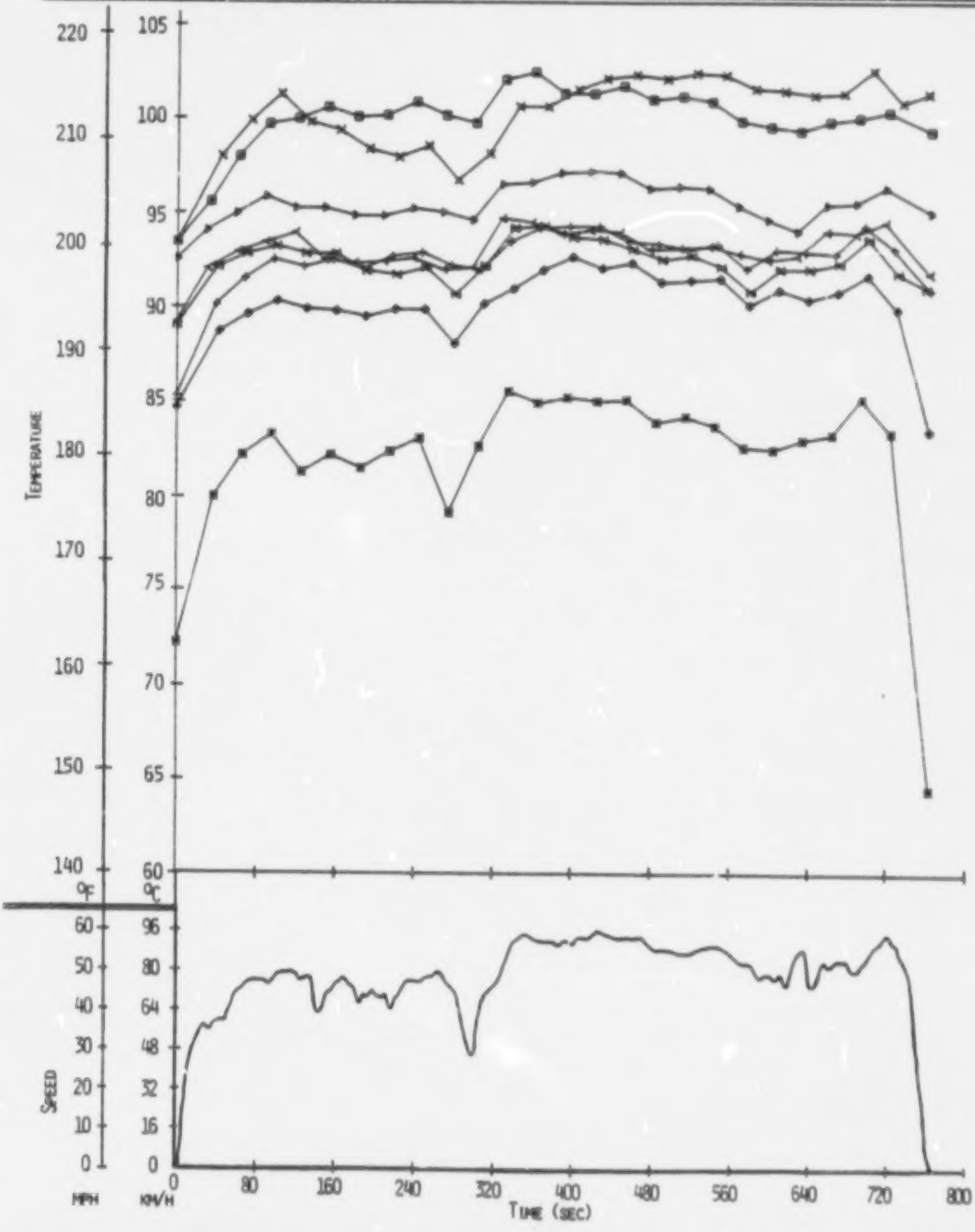
Propane Carburetion
V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND

	TEST #	TEST TEMP. °C	HARDWARE CONFIG.
⊡ —	9.1.2-2	25	A
▷ —	9.1.3-1	0	A
+ —	9.1.4-1	-20	A[1]
< —	9.1.4B-1	-20	A - with 2 hr block heat preheat
N —	9.1.5-3	-35	A[2]- with 5 hr block heat preheat
× —	9.2.2-1	25	B
◇ —	9.2.3-1	0	B
✳ —	9.2.4-1	-20	B[3]

Notes:
1. Additional 120 sec idle period performed prior to start of test cycle.
2. Additional 150 sec idle period performed prior to start of test cycle.
3. Additional 130 sec idle period performed prior to start of test cycle.



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 138

VEHICLE NO: 9 PROPANE

TEST NO: 9.1.4B-1

TEST TEMPERATURE: -20 C

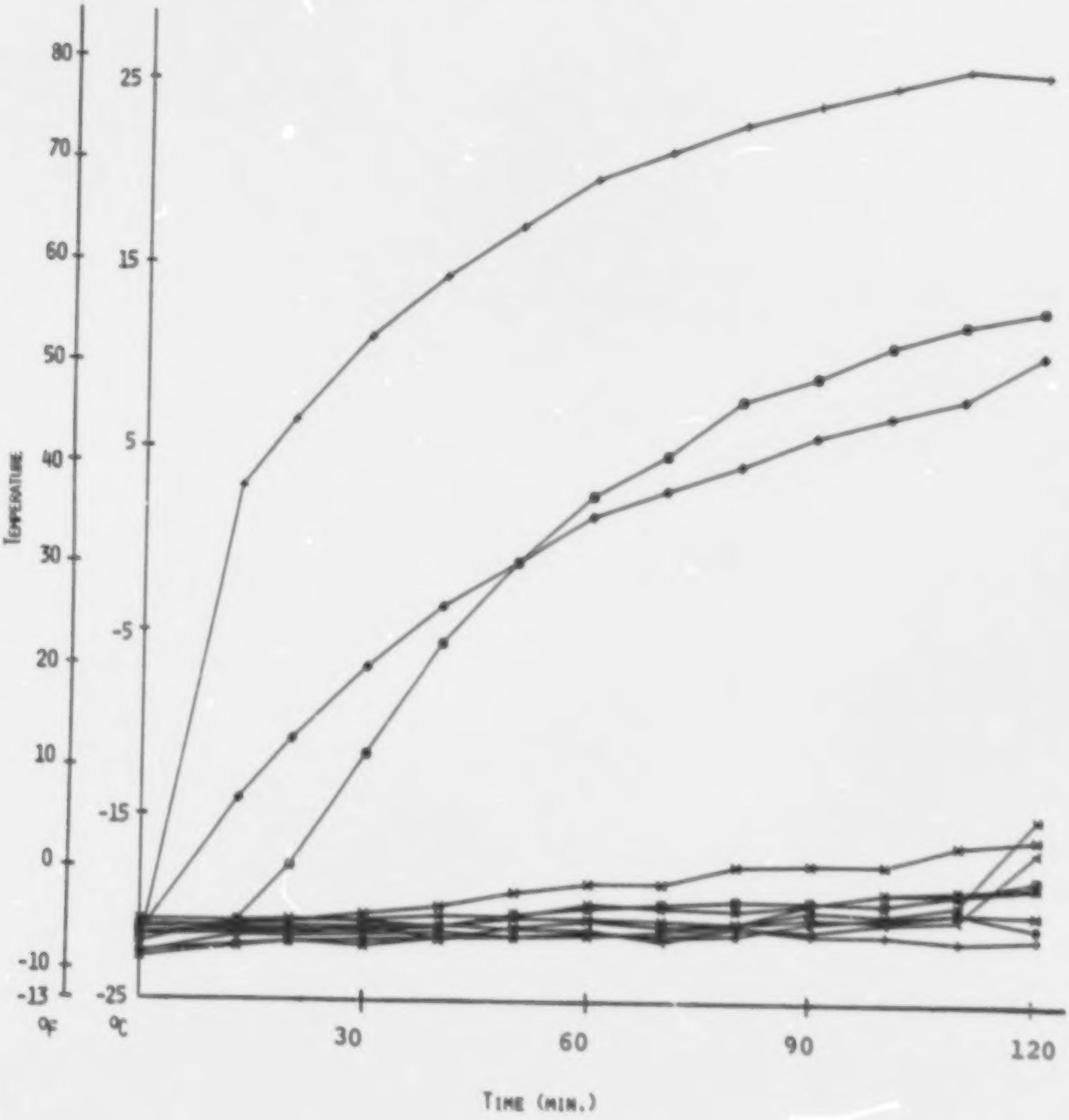
BLOCK HEATER WARMUP
TEMPERATURE TRACE

HARDWARE CONFIGURATION A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✚ — Coolant - Lower Rad. Hose
⊙ — Coolant - Heater In
✕ — Carb. Air In
◈ — Int. Manifold Runner
⌛ — Eng. Oil @ Dipstick
● — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⋊ — In Car Temp.
⧓ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out



TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM - PHASE II

Figure 139

VEHICLE NO: 9 PROPANE

TEST NO: 9.1.5-3

TEST TEMPERATURE: -35 C

BLOCK HEATER WARMUP
TEMPERATURE TRACE

HARDWARE CONFIGURATION A - RESTRICTION IN COOLANT BYPASS,
VAPOURIZER COOLANT FLOW PARALLEL TO BYPASS

Base Vehicle: 1980 'L' Car with 9.3:1 Comp. Ratio 1.7L Engine,
Propane Carburetion V.I.N.# 118220

Note: Tests run with high volume cooling fan, hood closed, and heater controls and dyno H.P. setting adjusted for test temperature.

LEGEND (VEHICLE 9)
+ — Coolant - Thermostat
✦ — Coolant - Lower Rad. Hose
⊖ — Coolant - Heater In
▷ — Coolant - Heater Out
× — Carb. Air In
◈ — Int. Manifold Runner
⌑ — Eng. Oil @ Dipstick
✱ — Trans. Oil @ Dipstick
≺ — Heater Duct - Left
⋈ — Heater Duct - Right
⤫ — In Car Temp.
⋈ — Fuel - Vapourizer In
⊡ — Coolant - Vapourizer Out

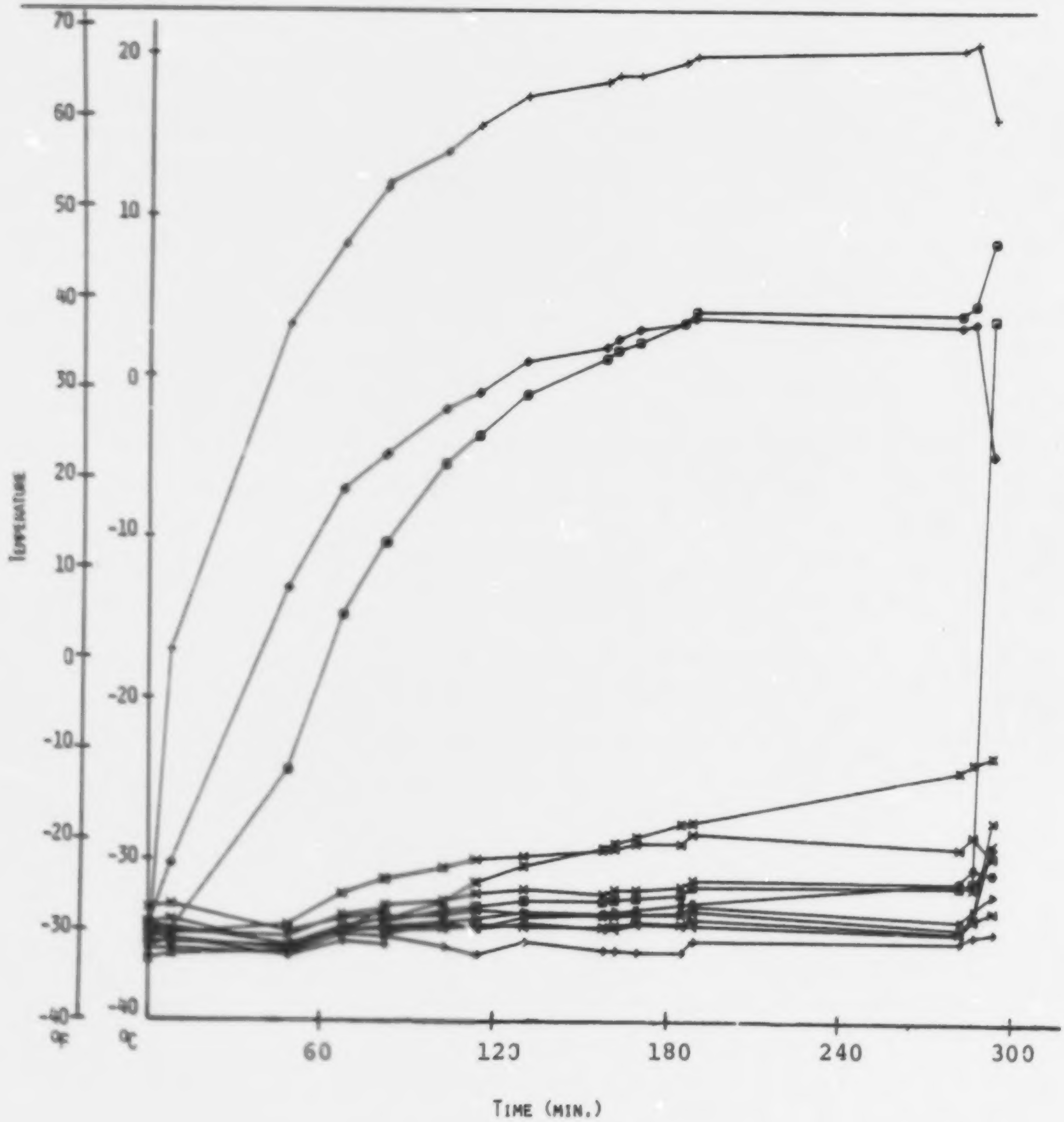


FIGURE 140

PERCENT IMPROVEMENT IN FUEL CONSUMPTION OVER BASE VEHICLE FOR OPTIMUM COLD TIMING CONFIGURATION

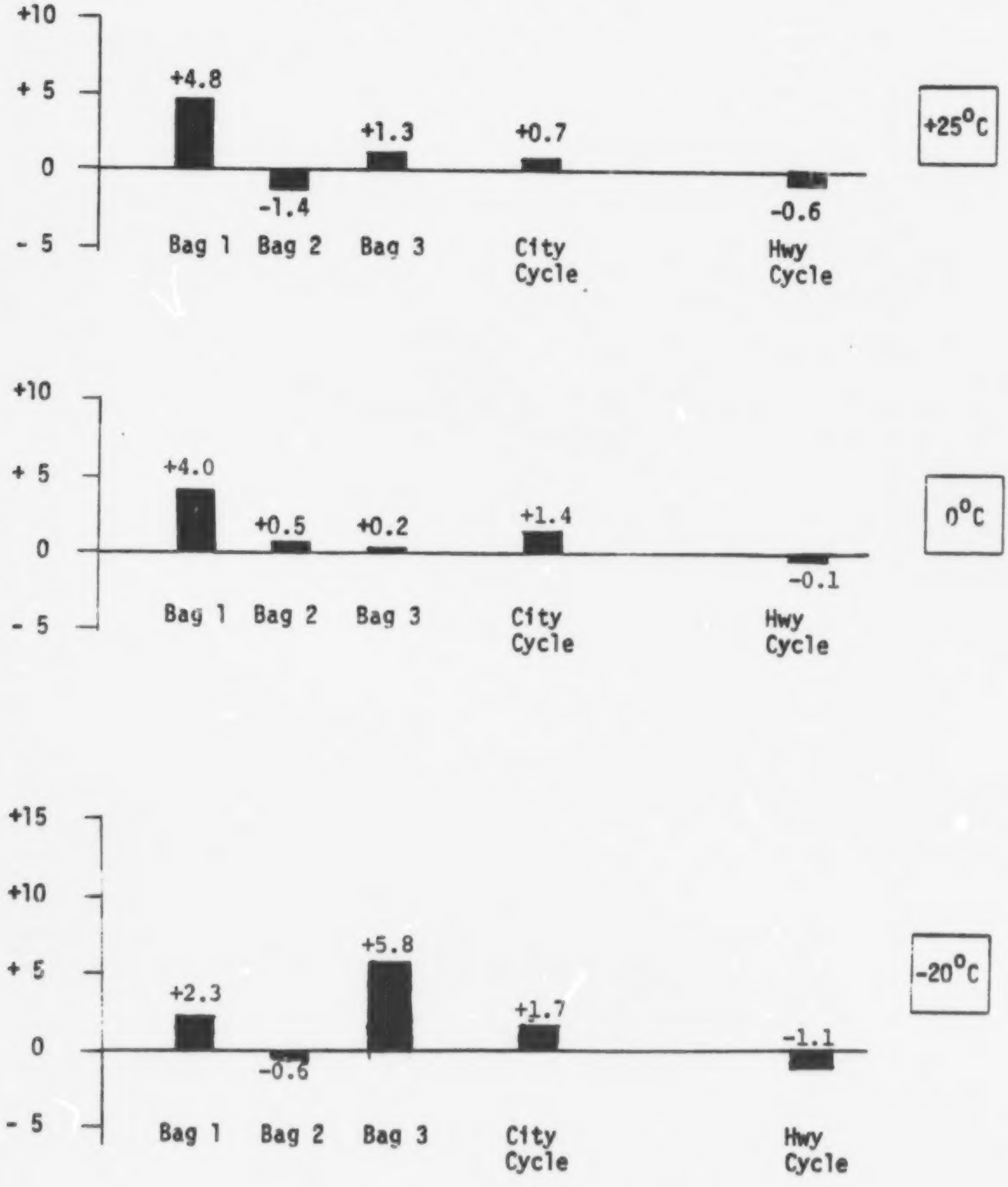


FIGURE 141

PERCENT IMPROVEMENT IN FUEL CONSUMPTION OVER BASE VEHICLE FOR AUTOMATIC IDLE SPEED CONFIGURATION

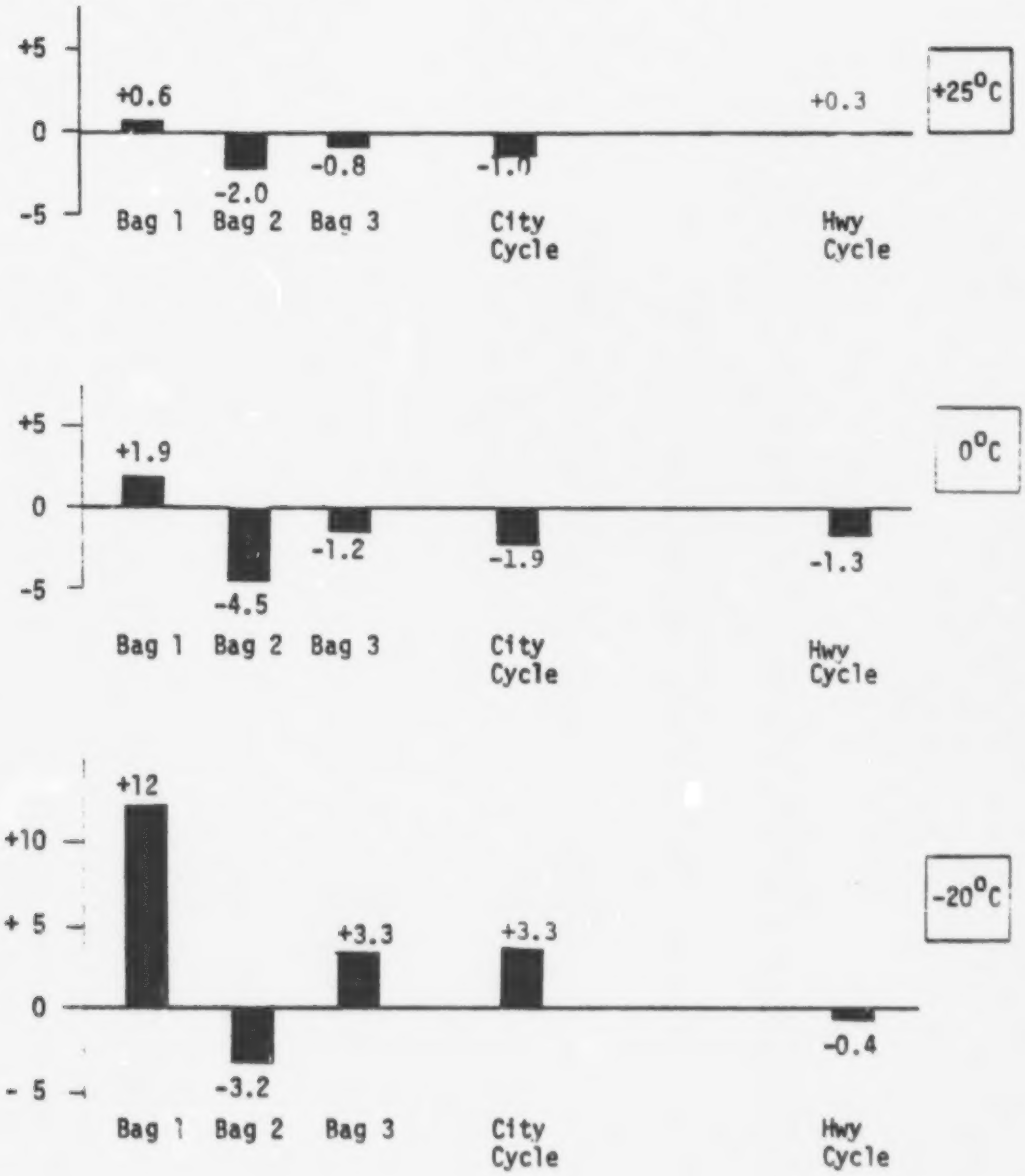
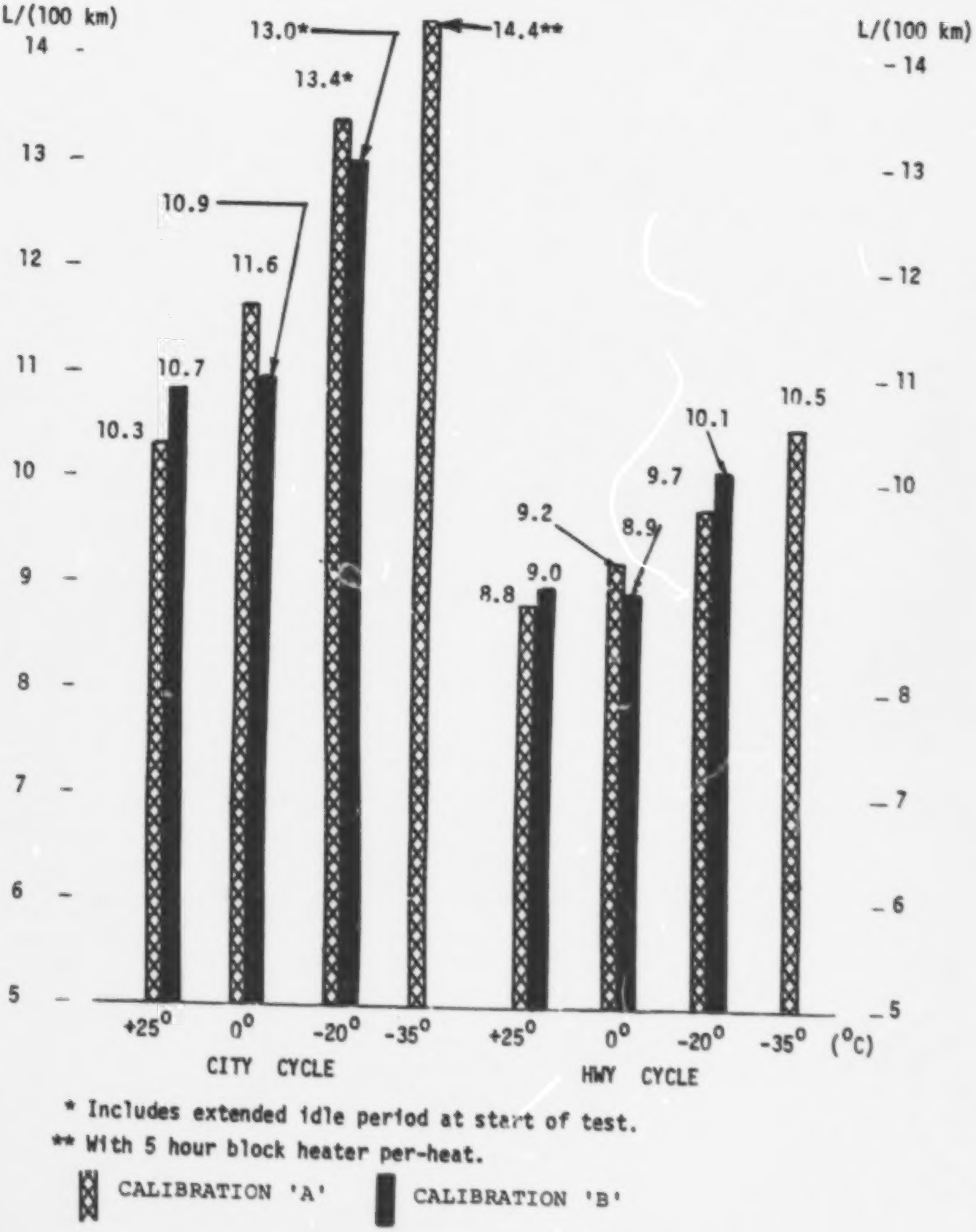


FIGURE 142

FUEL CONSUMPTION VS TEST TEMPERATURE FOR PROPANE VEHICLE - CALIBRATIONS A & B



* Includes extended idle period at start of test.

** With 5 hour block heater per-heat.

FIGURE 143

CITY CYCLE EXHAUST EMISSIONS VS TEST TEMPERATURE FOR PROPANE VEHICLE - CALIBRATIONS A & B

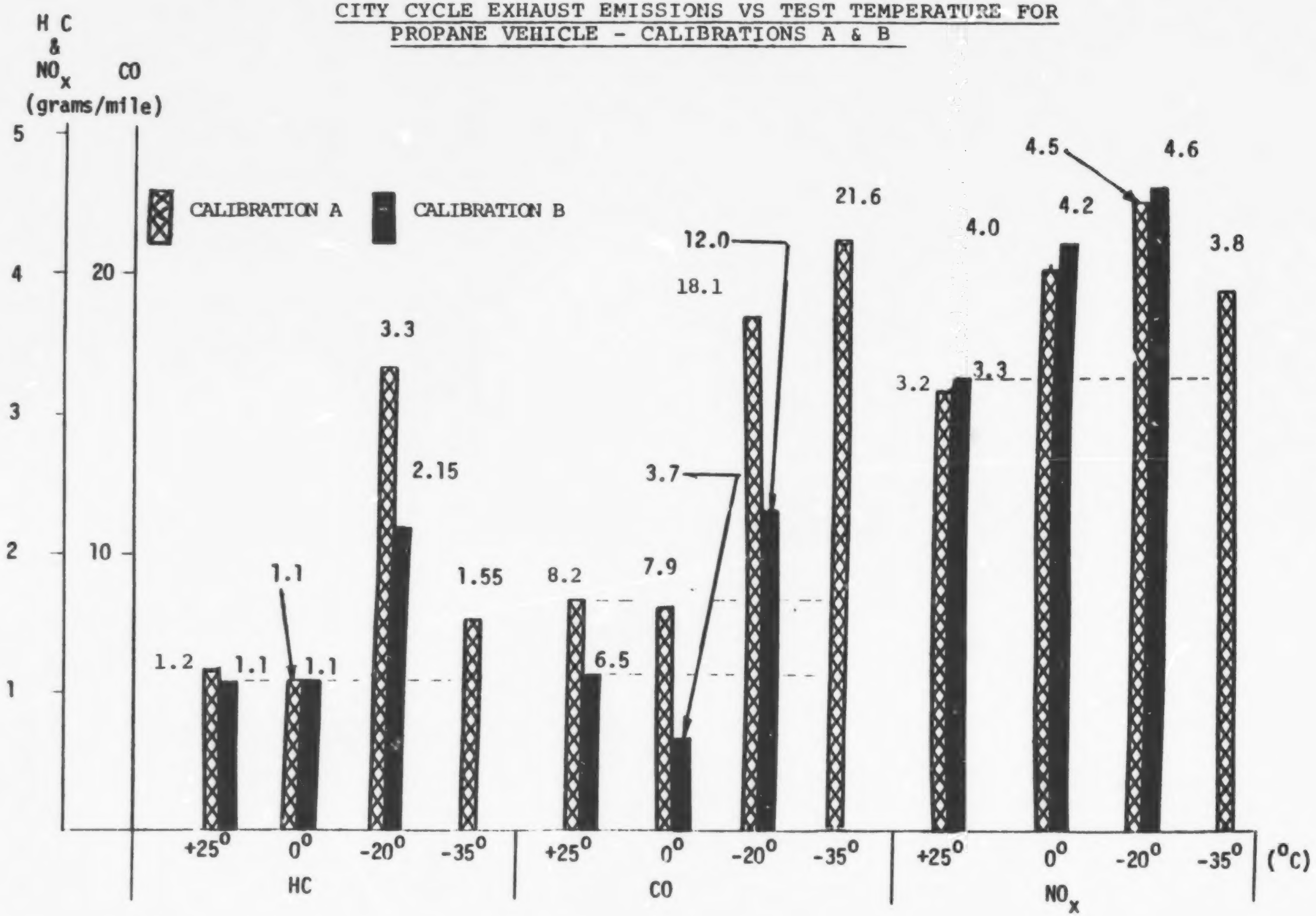
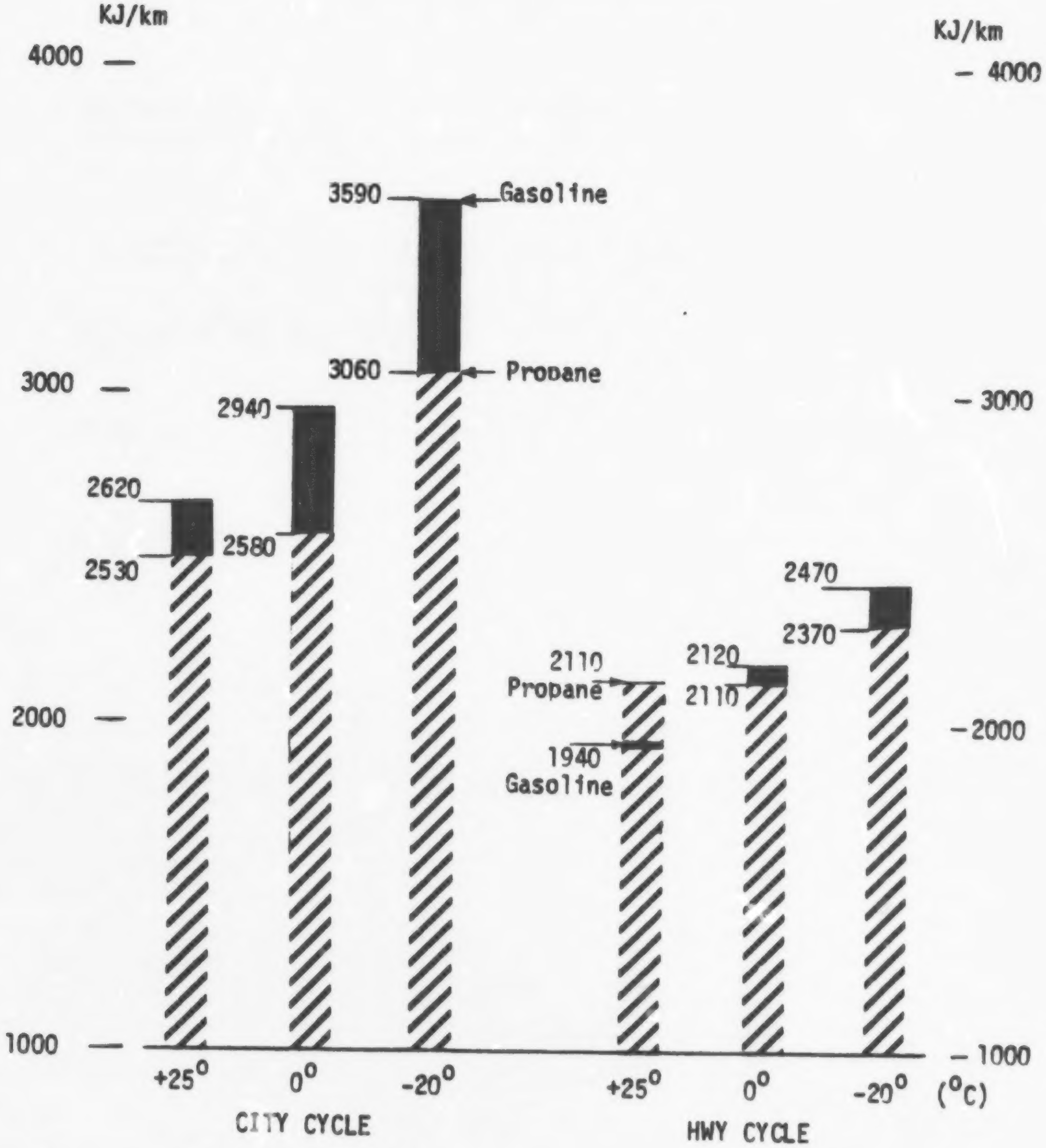


FIGURE 144

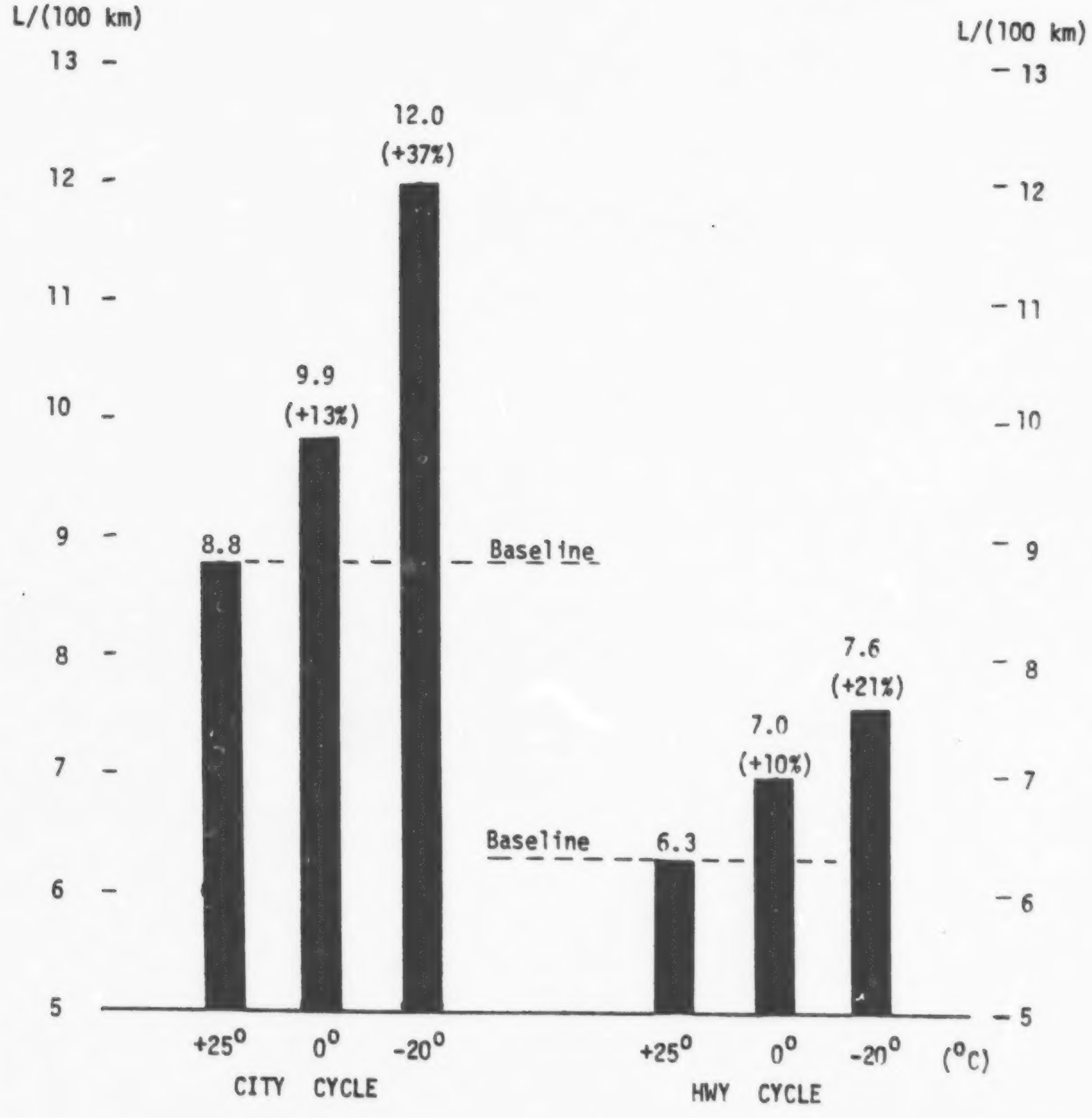
ENERGY CONSUMPTION VS TEMPERATURE FOR BASE GASOLINE VEHICLE #3 AND PROPANE VEHICLE #9 (CALIBRATION B)



Comparison based on carbon balance methods for computing fuel consumption.

FIGURE 145

FUEL CONSUMPTION VS TEST TEMPERATURE FOR BASE GASOLINE VEHICLES IN PHASE II -ONE VEHICLE (#3) ONLY.

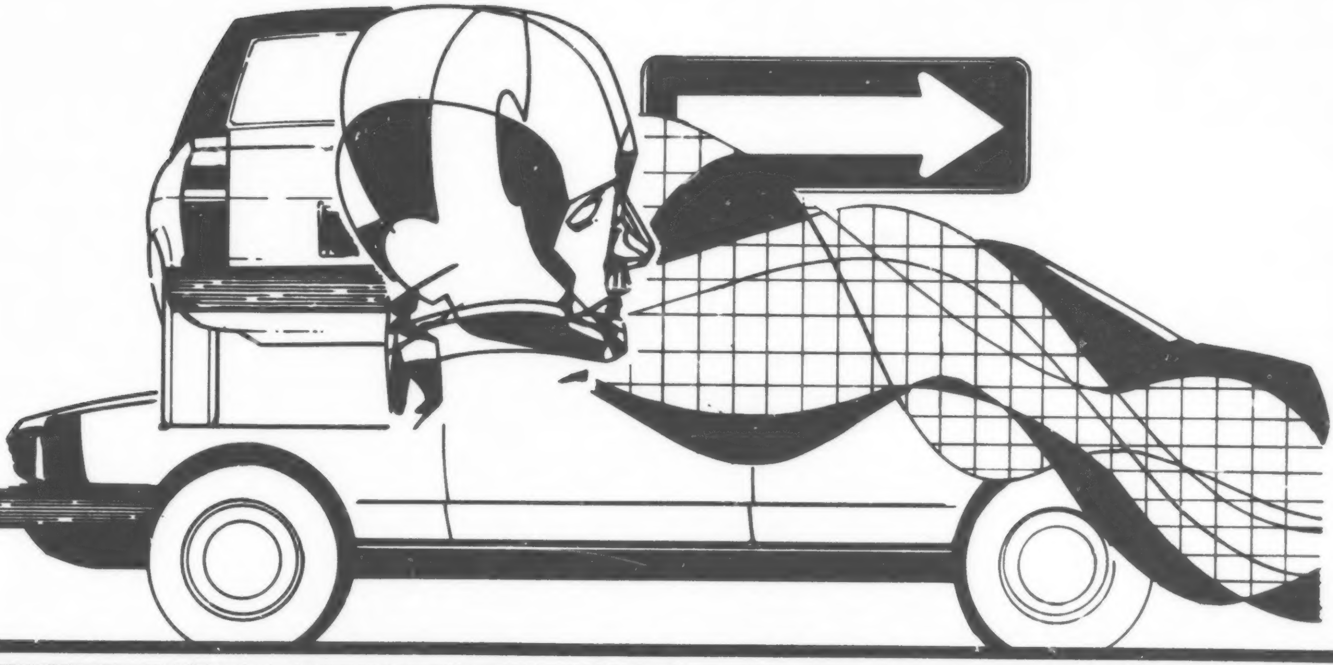


Volume

2

EVALUATION OF POTENTIAL IMPROVEMENTS IN AUTOMOBILE FUEL CONSUMPTION AT LOW TEMPERATURE - PHASE II

VOLUME II - APPENDICES



Transport Canada　Transports Canada

Road Safety　Sécurité routière

TP 4077E

FINAL REPORT

EVALUATION OF POTENTIAL IMPROVEMENTS IN AUTOMOBILE FUEL CONSUMPTION AT LOW TEMPERATURES - PHASE II

VOLUME 2 - APPENDICES

Prepared For:

TRANSPORT CANADA
OTTAWA, ONTARIO

Prepared By:

DAVIS ENGINEERING LIMITED
CONSULTING ENGINEERS
OTTAWA, ONTARIO

DSS FILE NO: 23SU.T8080-1-9016
DE FILE NO: C81-140

AUGUST 1982

LIST OF APPENDICES

APPENDIX A Vehicle Driveability Evaluation Procedure

APPENDIX B Vehicle Tuneup Procedures

APPENDIX C Cold Weather Program Scheduled Test Vehicle Maintenance Operations and Record

APPENDIX D Road Load Power Control Factory Calibration Procedure

APPENDIX E Basic Electrical (RLPC) Calibration Procedure

APPENDIX F Procedure For Determining Dynamometer Frictional Power Losses

APPENDIX G Procedure For Plotting Torque Versus Speed and HP Versus Speed Curves

APPENDIX H Propane Fuel Consumption Correction Factor

APPENDIX I Dynamometer Horsepower Calculations For Different Test Temperatures

APPENDIX J Transport Canada Driving Cycles

APPENDIX K Cold Weather Test Program Formal Lab Procedure and Test Data Summary

APPENDIX L Vehicle Test Tolerances - Test Quality Control Data

APPENDIX M Fuel Consumption and Exhaust Emissions Calculation Computer Program

APPENDIX N Vehicle #3 Automatic Idle Speed Maintenance Calibration Specifications

APPENDIX A

Vehicle Driveability Evaluation Procedure

[redacted]

S.I.D. (START, IDLE, DRIVE) VEHICLE DRIVEABILITY EVALUATION PROCEDURE

Under the "S.I.D." vehicle driveability rating system, vehicles [redacted] are evaluated for several functions under various vehicle conditions.

FUNCTIONS:

- Engine Starting
- Idle Rating
- Car In Motion - Driveability
- Performance
- Spark Knock
- Stalls

CONDITIONS:

- Cold
- During Warm-Up
- Warmed-Up
- After Hot Soak
- After Partial Cool-Down

A 1 to 9 (9 is best) numerical rating system is used for the rating functions. The rating number is intended to represent the driver satisfaction level. Table 1 defines the satisfaction levels in general terms. Tables 2, 3, 4 and 5 relate these same definitions to the Start, Idle, Drive and Performance respectively.

Downgrade for stalling is reflected in the appropriate S.I.D. function. Spark knock is noted separately from the drive evaluation.

I. STARTING

Vehicles are to be started in accordance with the procedure printed on Attachment 7. Starting performance is to be rated in accord with Table 2.

Die-outs and passouts occurring after a start, but before the car has been moved from the parking space, should be included in the starting rating by downgrading the potential starting rating in accordance with the severity of the condition experienced. A die-out is defined as an engine stall with the throttle in the closed position irrespective of vehicle movement.

Note: In cold starting a vehicle, the throttle is open to a fast idle cam position. It will be assumed that in this position, the throttle is closed since the throttle is against the designed stop.

A passout is an engine stall with throttle movement irrespective of vehicle movement. Downgrading of start due to stalls is in accordance with Table 2.

An asterisk (*) should be added to any rating which is downgraded for a stall.

A cold-start is defined as a vehicle which before being started, has been thoroughly warmed to normal operating condition, then soaked for a minimum of eight hours and a maximum of 18 hours. Three rating scales for different ambient temperature ranges are used (Table 2). Care must be exercised to use the correct rating scale for the appropriate temperature range.

A hot-start is one in which a fully warmed-up engine has soaked approximately .2 (12 min.) to .8 (48 min.) of an hour, dependent on ambient temperature. Hot-start is rated only above 10°C(50°F).

A partial cool-down (PCD) start is one in which the restart is applied to a vehicle fully warmed, after a soak of 1.5 to 4 hours. Both partial cool-down and hot start are illustrated graphically in Attachment 8. The importance of correctly noting soak time, ambient temperature and start time when starting vehicles is stressed.

II. IDLE

The idle quality will be rated using a 1 to 9 scale, with the vehicle in gear (except for manual transmission vehicles). On vehicles equipped with air conditioning, the idle quality should be noted both with A/C and without A/C operational. Idle ratings placed in the S.I.D. matrix are without A/C operational. Idle ratings will not be downgraded for stalls as done for start, since idle ratings of 1 thru 3 will define this condition. Idle quality is to be rated in accord with Table 3. An asterisk(*) should be used whenever a dieout occurs.

III. DRIVE

The drive evaluation is comprised of four distinct areas: Cold (during warm-up); Warm; Hot; and Partial Cool-Down (PCD). The cold drive is judged from the point when the vehicle is placed in gear, after the cold start, and begins to move to the point of temperature equilibrium. An indication of equilibrium in the coolant temperature gauge indicates the end of the cold period. Cold drive will be evaluated by a series of light

III. DRIVE (Cont'd.)

tip-ins (LTI), and heavy tip-ins (HTI) from rest, at one-tenth mile increments for the first mile, and two-tenth increments between one and three miles.

A fully warmed-up drive is the condition after the cold period is ended or when the engine has reached equilibrium. Warm drive is evaluated by driving the vehicle at various steady state speeds and acceleration modes from the steady state speeds indicated on the drive evaluation sheet. It should be noted that the acceleration modes during warm drive should not necessarily involve a downshift since this is evaluated in performance.

Hot drive is the portion of the evaluation which takes place after the fully warmed-up vehicle has soaked for a period of .2 (12 min.) to .8 (48 min.) of an hour. The vehicle is then started and driven away, utilizing a light tip-in. The drive evaluation should continue to temperature equilibrium. Ambient temperature must be above 10°C (50°F).

Partial cool-down (PCD) drive takes place after the fully warmed-up vehicle has soaked for a period of 1.5 to 4 hours. The vehicle is then started and driven away using a light tip-in. The drive rating includes all characteristics until the vehicle is warmed-up to equilibrium.

If the evaluator is uncertain of when temperature equilibrium occurs, the following guidelines may be used:

Hot Start - 3 Minutes
Cold Starts Above 10°C (14°F) - 10 Minutes
Partial Cool Down - 10 Minutes
Cold Starts Below 10°C (14°F) - 15 Minutes

The importance of comments in all aspects of the driveability evaluation is emphasized. Any peculiarities of the evaluation should be noted. Drive evaluation is to be rated in accord with Table 4. An asterisk (*) should be used whenever a dieout or passout occurs.

IV. PERFORMANCE

Performance rating is a relative indicator of how well the vehicle performs under heavy acceleration. Examples of performance evaluation would be WOT or nearly WOT acceleration from standing start, a high speed freeway traffic maneuver, or when merging into high speed freeway traffic from an entrance ramp. The rating must take into account which particular engine displacement/inertia weight/axle ratio combination is being evaluated. [redacted]

Since vehicle performance is difficult to measure accurately without the aid of stop watch, speedometer and test track, the subjective guidelines in Table 5 are to be used.

V. EXAMPLE

Following is an example of a completed evaluation matrix.

	COLD	WARM	HOT	PCD
START	5*	X	8	6
IDLE	6	5	5	3*
DRIVE	7	8	8	3*
PERFORMANCE	X	8	X	X

Cold Portion

The 5* rating represents a 3.0 second cold start time (above +20°F) with the rating downgraded 2 points for one die-out. The 6 idle rating represents idle quality with slight engine roughness and the 7 cold drive rating indicates driveability having one or more undesireable elements, but taking concentration to find.

Warm Portion

The 5 idle rating represents an irritating condition. A definite undesireable condition exists, but not to the extent that it is disturbing. The 8 driveability represents a trace of only one undesireable element that can be found. The 8 performance rating indicates a vehicle that under heavy acceleration, performs better than the customer would expect considering engine displacement/inertia weight/axle ratio combination.

Hot Portion

The 8 start represents a 1.1 to 2.0 second crank with no die-outs. The 5 idle rating would be the same as described in the warm section and the 8 drive would also be the same as in the warm section.

PCD

The 6 start represents a 3.1 to 4.0 second crank with no die-outs. The 3 idle rating indicates an idle that would give the evaluator lack of confidence. The vehicle had die-outs and extremely rough idle. The 3 drive represents a condition that undermines the driver's confidence in the car's ability to perform reliably at all times.

[redacted]

[redacted]

"ATTACHMENTS"

1. Rating Definitions in Terms of Customer Satisfaction.
2. Start Ratings.
3. Idle Ratings.
4. Drive Ratings.
5. Performance Ratings.
6. Glossary of Driveability Terms.
7. Starting Procedure.
8. Vehicle Cool-down Curve.

[redacted]

Table 1

"RATING DEFINITIONS IN TERMS OF CUSTOMER SATISFACTION"

9. Exceptional - No defects; driver is truly impressed.

8. No Significant Deficiencies - Only traces of deficiencies can be found; driver is pleased.

7. Minor Deficiencies - Few deficiencies, all minor in nature; driver is satisfied.

6. Obvious, But Not Objectionable Problems - A definite undesireable characteristic exists; however, the driver does not consider it objectionable. Driver is generally satisfied.

5. Marginal - Borderline, driver is not particularly happy with car operation, but is not likely to complain unless irritated for some other reason.

4. Disturbing - An owner would seek corrective action.

3. Lack of Confidence - Condition is so severe as to cause driver to loose confidence in the ability of the vehicle to perform reliably, though failure to perform is rare.

2. Unreliable - Periodic failure to perform.

1. Unpredictable - Erractic and uncontrollable failure to perform.

Table 2

"START RATING"

	START TIME	RATING ALL STARTS EXCEPT COLD STARTS BELOW -8°C(20°F)	 COLD STARTS BETWEEN -8°C + -18°C (20°F + 0°F)	 COLD STARTS BETWEEN -18°C + -30°C (0°F + -20°F)
START TIME Time applies to either first start or any subsequent restart, whichever is the longest.	1.0 or Less	9	9	9
	1.1 - 2.0	8	9	9
	2.1 - 3.0	7	8	9
	3.1 - 4.0	6	8	8
	4.1 - 5.0	5	7.	8
	5.1 - 6.0	4	6	7
	6.1 - 7.0	3	5	7
	7.1 -8.0	2	5	6
	8.1 -9.0	2	4	5
	9.1 -10.0	1	3	5
	10.1 - 12.0	0	2	4
	12.1 - 14.0	0	1	3
	14.1 - 15.0	0	0	1
	Over 15	0	0	0
	STALLS			
STALLING DOWNGRADE	1	2	1	1
	2	5	3	2
	3	6	5	3
	4 or More	7	7	1 per START

Table 3

"IDLE RATING"

RATING	DEFINITION
9	No trace of an undesirable element can be found and one cannot feel that the vehicle is running.
8	Engine operation is barely perceptible. Idle is totally smooth and flawless.
7	Engine vibration is noticeable but smooth and unobjectionable.
6	Consistent idle speed with slight engine roughness.
5	This would be an irritating condition, such as a moderately rough or pulsating idle.
4	Disturbing: An engine operation problem exists which is disturbing to the driver but is not serious enough to undermine the driver's confidence in the car's ability to continue running. An idle that causes severe driveline shock upon engagement or is very rough. This would be considered unacceptable.
3	Lack of Confidence: A condition exists which undermines the driver's confidence in the car's ability to perform reliably at all times. (Examples are extremely rough idle or decel die-outs after the vehicle comes to rest.)
2	Frequent die-outs.
1	Multiple die-outs, operation is erratic and uncontrollable.

Table 4

"DRIVE RATING"

RATING	DEFINITION
9	No trace of any undesireable element can be found and in addition, the car has exceptionally good responsive feel under all conditions.
8	Traces of undesireable elements can be found with extreme concentration or no undesireable characteristics but lacking the responsiveness and feel of a 9 rating.
7	One or more undesireable characteristics can be found, but take concentration to find. (Examples are light surge or off idle flatness.)
6	The undesireable characteristic(s) are definitely noticeable, but not objectionable. (Examples are moderate surge, sags, and/or stumbles.)
5	The undesireable characteristic(s) are obvious and somewhat irritating and may result in a customer complaint. (Examples are medium surge, sags, and/or stumbles.)
4	Disturbing: An engine operation exists which is disturbing to the driver but is not serious enough to undermine the driver's confidence in the car's ability to continue running. (Examples are heavy surge, sags, and/or stumbles.) The customer would definitely seek corrective action.
3	A condition exists which undermines the driver's confidence in the car's ability to perform reliably at all times. (Examples are severe surge, sags and/or stumbles.)
2	A failure of the engine to continue running. (Examples are passouts that could be driven around or decel die-outs which occur while the vehicle is still in motion.)
1	A condition exists which could cause unpredictable driveability during normal operations. This rating would generally apply to moving passouts which cannot be driven around.

PERFORMANCE

NO.	DEFINITION
9	The vehicle would have an exceptionally good responsive feel under all conditions.
8	Vehicle's performance is above average. Driver feels the car has better performance than he expected.
7	Driver feels vehicle's performance is what it should be.
6	**Satisfactory:** Driver feels vehicle does not perform as well as he thought it would but he would not return the car for a performance complaint.
5	**Borderline:** Vehicle does not perform as well as driver thought it would. A customer may complain and ask that the vehicle be checked for proper operation (e.g., poor passing and acceleration capability under normal conditions).
4	**Disturbing:** An engine performance problem exists which is disturbing but is not serious enough to undermine the driver's confidence in the car's ability to pass another vehicle. A customer would be unhappy with product and require that the condition be corrected.
3	**Lack of Confidence:** Vehicle performance is so weak that the driver lacks the confidence required to try a passing maneuver.
2	Vehicle performance is so weak that the driver is reluctant to operate vehicle on public roads.
1	**Undefined**

Table 6

GLOSSARY OF DRIVEABILITY TERMS

After Running:

Engine continues to run after the ignition is turned off. Sometimes referred to as "dieseling" although this is not an accurate description of the condition and After-Running is preferred.

Backfire:

Combustion of the unburned air-fuel mixture which takes place in the exhaust system rather than in the combustion chamber. Resulting combustion pressure exits through the muffler and tailpipe.

Detonation or Spark Knock:

Engine "knock" that occurs only when accelerating. Usually associated with medium to heavy throttle acceleration or lugging at relatively low speeds especially with a manual transmission. However, it may occur in higher speed ranges under heavy load conditions. Caused by advance timing or low octane fuel.

Die-Out:

An engine stall with the throttle in the closed position irrespective of vehicle movement.

Flat Spot:

Lack of normal acceleration or response to throttle opening ... no loss of power, but no increase. Engine does not miss or die as in the case of Cut-Out or Pass-Out.

Hesitation:

Momentary lack of throttle response at some car speed.

Miss:

Short for misfires or failure to ignite the mixture in one or more cylinders. This condition may be intermittent or continuous on one or more cylinders.

Pass-Out:

An engine stall with throttle movement irrespective of vehicle movement.

Pop-Back:

Mixture in the intake manifold is ignited and the resulting combustion takes place outside of the combustion chamber so that it may "pop-back" through the carburetor.

Sag:

Lack of normal acceleration or response to the initial movement of the throttle followed almost immediately by normal response. A sag is severe hesitation.

Stumble:

Lack of response to initial movement of the throttle from a standstill.

Surge:

Engine speed increases and decreases slightly but perceptibly in spite of the fact that the driver has not changed throttle position.

Vapor Lock:

Slow hot start or won't start condition caused by vaporization of the fuel in the fuel lines. As a result, liquid fuel is not delivered to the carburetor.

TO START ENGINE

COLD ENGINE OR FIRST
START OF DAY (Above 0°F)

Press accelerator pedal to floor and slowly remove foot from pedal. Turn key to "START" and hold until engine runs, then release key.

If engine speed seems excessive, lightly depress and release pedal five seconds after start.

WARM ENGINE

Press accelerator pedal 1/3 of the way down and hold. Turn key to "START" and hold until engine runs, they release key and pedal.

EXTREMELY COLD ENGINE (Below 0°F)

Press accelerator pedal to the floor and release. Then hold pedal 1/3 of the way down. Turn key to "START" and hold until engine runs, then release key and pedal.

IF ENGINE FAILS TO START

If engine fails to start after cranking for 15 seconds, stop cranking, and after one minute repeat the proper procedure.

If repeated starting attempts are unsuccessful, the engine may be "loaded" with gasoline. In this instance, the following procedure should be followed:

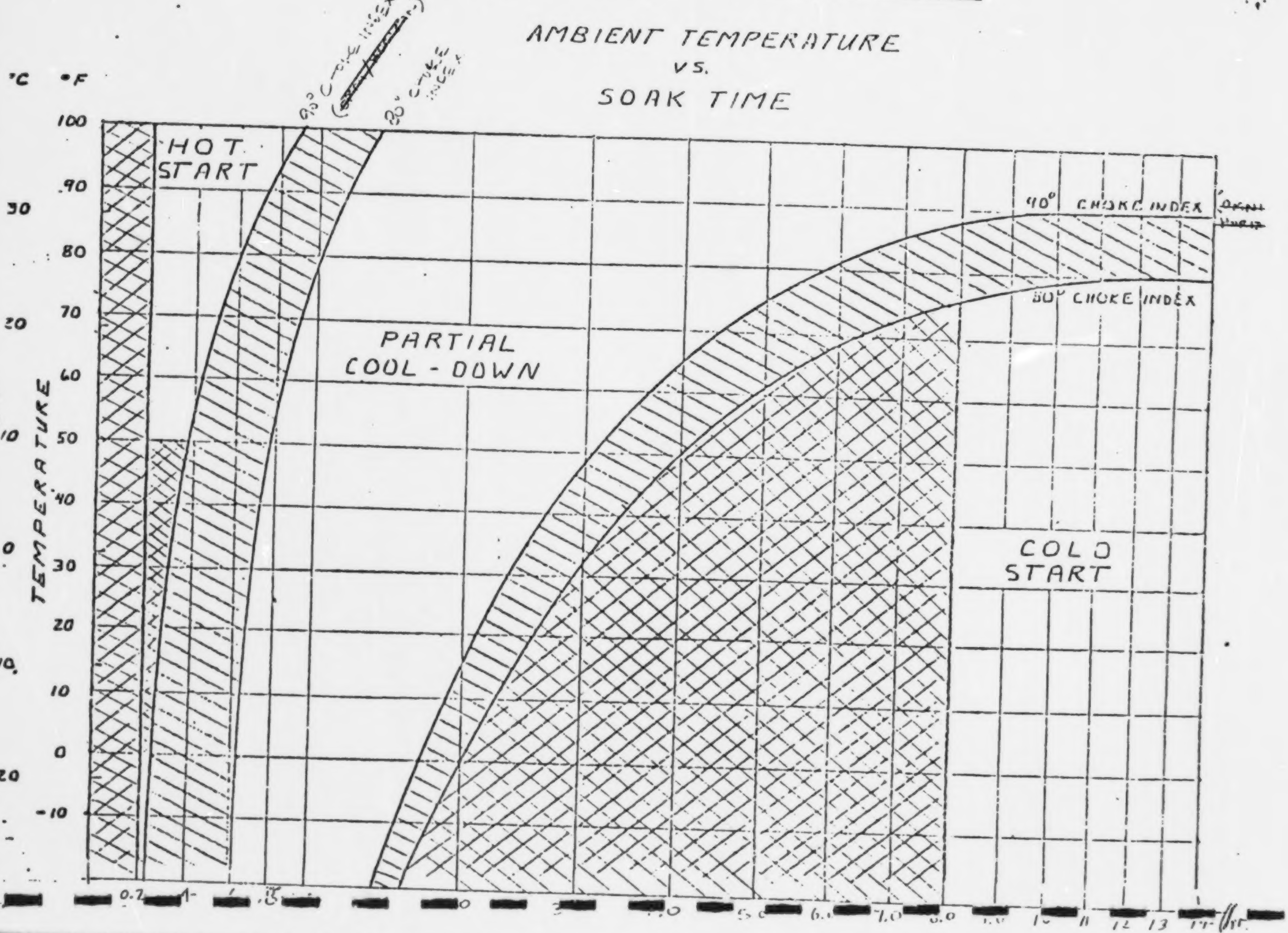
1. Press the accelerator pedal all the way to the floor and hold firmly. DO NOT PUMP THE PEDAL.
2. Turn key to "START".
3. Release key when engine starts.
4. Release pedal gradually as engine speeds up.

CAUTION: Do not hold key in "START" position longer than 15 seconds at a time.

CAUTION: Cold start difficulty can result if ignition is left in "ON" position when engine is not running.

ATTACHMENT VIII

DRIVEABILITY COOL-DOWN RATE



DRIVEABILITY EVALUATION REPORT

DATE: ____________________ VEHICLE ID: ____________________

DRIVER: ____________________ TEST NO: ____________________

TEST ENGINEER: ____________________

S.I.D. RATING SUMMARY

	COLD	WARM	HOT	PCD
START		X		
IDLE				
DRIVE				
PERFORMANCE	X		X	X

COLD START

Time (Start of Soak) ____________________

Time (End of Soak) ____________________

Soak Time ____________________

Overnight Low (°C) ____________________

Start of Test Temp. (°C) ____________________

Barometer (kPa) ____________________

Relative Humidity ____________________

Start Time (sec.) ______, ______, ______, ______

Die - Outs ____________________

Comments ____________________

WARM UP

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

FULLY WARMED UP

	RATING	COMMENTS
IDLE		
DRIVE ABILITY *		
50 KPH S.S		
ACCEL 50 - 65		
65 KPH S.S		
ACCEL 65 -90		
PERFORMANCE **		
ACCEL 0 - 65		
ACCEL 50 - 90		
ACCEL 80 - 100		

* Do not engage transmission downshifts in accels

** W.O.T. accels

RATING SUMMARY

IDLE	
DRIVE ABILITY	
PERFORMANCE	

HOT START

Soak Time ______________

Temperature (°C) ______________

Start Time (sec.) __________, __________, __________, __________

Die - Outs ______________

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

PARTIAL COOLDOWN

Soak Time ______________________

Temperature ('C) ______________________

Start Time (sec.) __________, __________, __________, __________

Die - Outs ______________________

	IDLE	COMMENTS	DRIVE	COMMENTS
0 Mile LT1				
.1 Mile MT1				
.2 Mile LT1				
.3 Mile HT1				
.4 Mile LT1				
.6 Mile HT1				
.8 Mile LT1				
1.0 Mile HT1				
1.2 Mile LT1				
1.4 Mile HT1				
1.6 Mile LT1				
1.8 Mile HT1				
2.0 Mile LT1				
2.2 Mile HT1				
2.4 Mile LT1				
2.6 Mile HT1				
2.8 Mile LT1				
3.0 Mile HT1				
OVERALL RATING				

NOTE: Continue driving vehicle until fully warmed up (i.e. stable coolant temperature)

APPENDIX B

Vehicle Tuneup Procedures

✓

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

VEHICLE TUNE-UP INFORMATION.

CONTENTS:

I. ITEMS TO BE CHECKED AND ADJUSTED BETWEEN EACH CHANGE IN TEST TEMPERATURE.

II. VEHICLE TUNE-UP SPECIFICATIONS.

III. VEHICLE TUNE-UP PROCEDURES.

PRODUCT ENGINEERING
CHRYSLER CANADA LTD.
82-03-29 (Revised)

I. ITEMS TO BE CHECKED AND AJUSTED BETWEEN EACH CHANGE IN TEST TEMPERATURE

(a) BASIC TIMING *

(b) CURB IDLE SPEED.

(c) PROPANE ENRICHED IDLE SPEED (WHERE APPLICABLE).

(d) HOT FAST IDLE SPEED.

(e) THROTTLE STOP SPEED.

* REPORT ANY DEVIATION OUTSIDE OF TOLERANCE TO CHRYSLER CANADA LTD.

VEHICLE TUNE-UP SPECIFICATIONS

VEHICLE #1, OPTIMUM COLD TIMING

NOTE: Before starting tune-up, ensure master switch is in "WARM" or "AUTO" position. (Position of other switches irrelevant).

ITEM	SPECIFICATIONS			TOLERANCE	ATTACHED PAGE NUMBERS AND SPECIAL NOTES.
	BASE CAR	CONFIG. A			
BASIC TIMING (°BTDC)	17°	17°		± 1°	Pg #6 - NOTE: LET ENGINE IDLE FOR MINIMUM 1 MINUTE BEFORE CHECKING TIMING.
CURB IDLE SPEED (RPM)	850	850		±25	Pg #8.
PROPANE ENRICHED IDLE SPEED (RPM)	950	950		±25	Pg #8
IDLE CO (%)	-	-			
HOT FAST IDLE SPEED (RPM)	1700	1400		± 50	Pg #11
THROTTLE STOP SPEED (RPM)	550	550		± 50	Pg #12
VACUUM KICK * (INCHES)	.040	.040		±0.005	Pg #13
CAM INDEX * (INCHES)	.040	.040		±0.005	No Page Number. SET ON 2nd STEP OF FAST IDLE CAM WITH NO VACUUM APPLIED TO KICK MECHANISM.
SPARK PLUG GAP	0.035"	0.035"			

* NOT REQUIRED TO BE CHECKED ROUTINELY. CHECK ONLY AT START OF PROGRAM AND IF ANY DEVIATION FROM SPECIFICATION IS SUSPECTED.

VEHICLE TUNE-UP SPECIFICATIONS

VEHICLE #3, AUTOMATIC IDLE SPEED - WITH SERVICE PROM INSTALLED.

ITEM	SPECIFICATIONS			TOLERANCE	ATTACHED PAGE NUMBERS AND SPECIAL NOTES.
	BASE CAR	CONFIG. A			
BASIC TIMING (°BTDC)	15^0	15^0		± 1	Pg #6 - NOTE: LET ENGINE IDLE FOR MIMIMUM 1 MINUTE BEFORE CHECKING TIMING.
CURB IDLE SPEED (RPM)	900	900		±25	Pg #8 - WITH SERVICE PROM INSTALLED AIS MOTOR OFF.
PROPANE ENRICHED IDLE SPEED (RPM)	1000	1000		±25	Pg #8 - WITH SERVICE PROM INSTALLED AIS MOTOR OFF.
IDLE CO (%)	-	-			
HOT FAST IDLE SPEED (RPM)	1700 (1)	3300 (2)		(1) ±50 (2) ±100	(1) Pg #11. (2) Pg #11 HIGH STEP OF ONE STEP CAM.
THROTTLE STOP SPEED (RPM)	N/A	N/A			
VACUUM KICK (INCHES)	0.040	0.040		±0.005	Pg #13.
CAM INDEX (INCHES)	0.040(1)	0.030(2)		±0.005	(1) No Page Number. SET 2nd STEP OF FAST IDLE CAM WITH NO VACUUM APPLIED TO KICK MECHANISM. (2) No Page Number. SET WITH THROTTLE CLOSED (OFF CAM) AND NO VACUUM APPLIED TO KICK MECHANISM.
SPARK PLUG GAP	0.035"	0.035"			

NOTE: Above specifications are tune-up specifications only with the service prom installed. Actual curb idle speeds with test proms installed may be different.

VEHICLE TUNE-UP SPECIFICATIONS

VEHICLE #9, PROPANE

ITEM	SPECIFICATIONS			TOLERANCE	ATTACHED PAGE NUMBERS AND SPECIAL NOTES.
		CONFIG. A	CONFIG. B		
BASIC TIMING (°BTDC)		20°	20°	± 1°	Pg #6 - NOTE: LET ENGINE IDLE FOR MINIMUM 1 MINUTE BEFORE CHECKING TIMING.
CURB IDLE SPEED (RPM)		900	900	±25	Pg #14
PROPANE ENRICHED IDLE SPEED (RPM)		N/A	N/A		
IDLE CO (%)		1.0	1.0	±0.2	Pg #14
HOT FAST IDLE SPEED (RPM)		1700	1700	±50	Pg #14
THROTTLE STOP SPEED (RPM)		N/A	N/A		
VACUUM KICK (INCHES)		N/A	N/A		
CAM INDEX (INCHES)		N/A	N/A		
SPARK PLUG GAP		0.035"	0.035"		

IGNITION TIMING PROCEDURE - VEHICLES 1, 3 & 9.

To obtain optimum engine performance, the distributor must be correctly positioned on the engine to give proper ignition timing.

Test procedures are as follows:

(1) Connect a suitable **Power Timing Light** to number one cylinder (refer to the equipment manufacturer's instructions for correct connecting procedures) or a suitable magnetic timing unit (use a 10° offset when required).

Do not puncture cables, boots or nipples with test probes. Always use proper adapters. Puncturing the spark plug cables with a probe will damage the cables. The probe can separate the conductor and cause high resistance. In addition breaking the rubber insulation may permit secondary current to arc to ground.

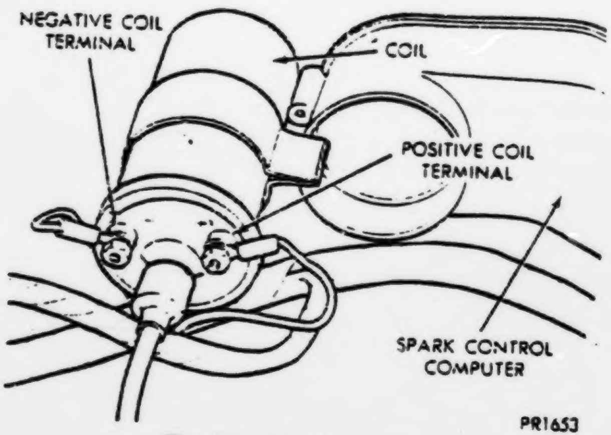


Fig. 17. Coil Terminals

(2) Connect red lead of the test tachometer unit to the negative primary terminal of the coil and the black lead to a good ground (Fig. 17).

(3) Turn selector switch to the appropriate cylinder position.

(4) Start engine and run until operating temperature is obtained.

(5) With engine at normal operating temperature (off fast idle), momentarily open the throttle and release to make sure there is no bind in the linkage and that idle speed screw is against its stop.

(6) On vehicles equipped with a carburetor switch, * connect a jumper wire between the carburetor switch and ground (Fig. 18).

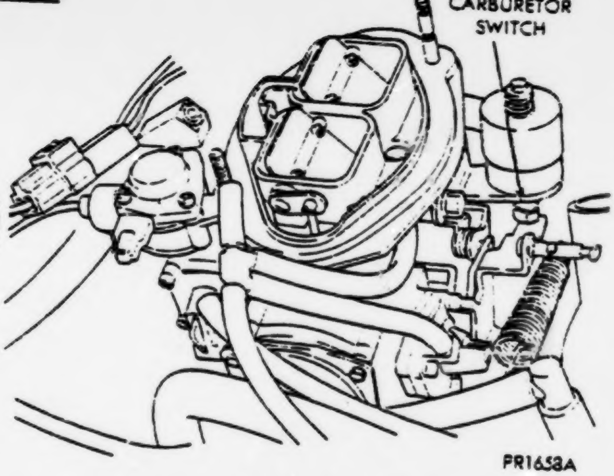


Fig. 18. Carburator Switch

(7) Read engine rpm on 1000 rpm scale. If the engine rpm is at or below 1000 RPM, proceed to the next step. If it is higher, turn the idle speed screw** UNTILL THE IDLE SPEED FALLS BELOW 1000 RPM.

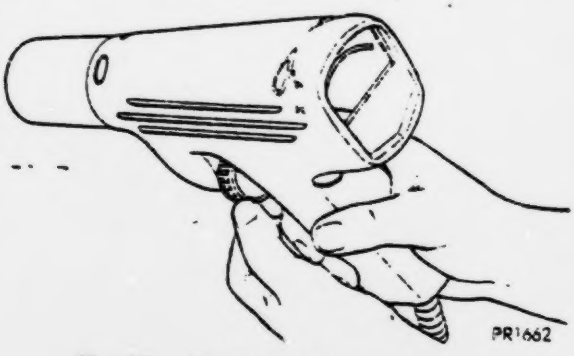


Fig. 19. Adjustable Timing Lamp

(8) Aim **Power Timing Lamp** (Fig. 19) at timing hole in bell housing (Figs. 20 and 21), or read magnetic timing unit. If flash occurs when timing mark is before specified degree mark, timing is advanced. To adjust, turn distributor housing in direction of rotor rotation.

If flash occurs when timing mark is after specified degree mark, timing is retarded. To adjust, turn distributor housing against direction of rotor rotation. If timing is within ± 1° of value specified proceed to step (10). If outside specified tolerance proceed to next step.

* Vehicles #1 and #9.

** Idle speed screw is located: Vehicle #1 - On top of solenoid.
Vehicle #3 - No Adjustment.
Vehicle #9 - Behind solenoid.

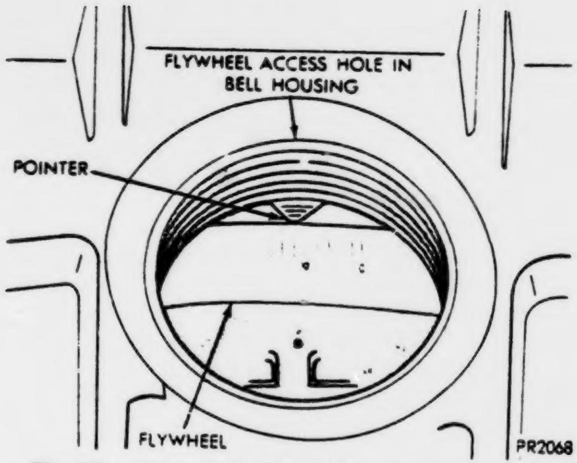

FLYWHEEL ACCESS HOLE IN BELL HOUSING
POINTER
FLYWHEEL
PR2068

Fig. 20. Timing Mark Location Manual A-412 Transaxle

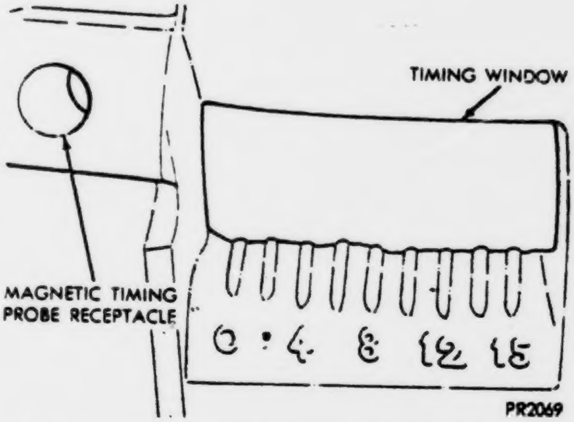

TIMING WINDOW
MAGNETIC TIMING PROBE RECEPTACLE
0
4
8
12
16
PR2069

Fig. 21. Timing Mark Location all Manual and Automatic Transaxles Except A-412 Manual Transaxle

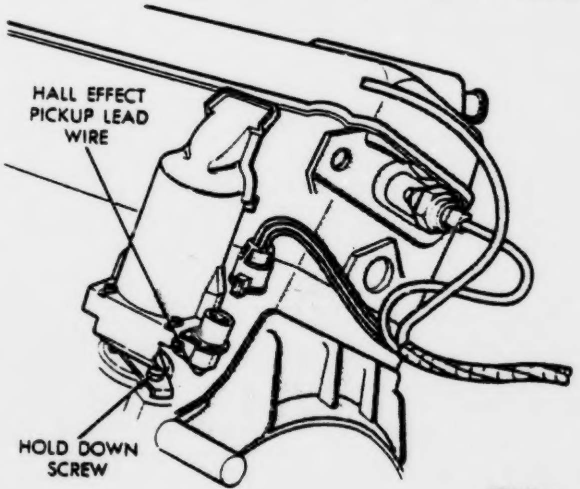

HALL EFFECT PICKUP LEAD WIRE
HOLD DOWN SCREW
PR1674A

Fig. 22. Distributor Hold Down 1.7L Engine

9) LOOSEN DISTRIBUTOR HOLD DOWN ARM SCREW JUST ENOUGH SO THE DISTRIBUTOR HOUSING CAN BE ROTATED IN ITS MOUNTINGS (Fig. 22). TURN DISTRIBUTOR HOUSING UNTIL SPECIFIED LABEL VALUE IS REACHED. TIGHTEN THE HOLD DOWN ARM SCREW AND RECHECK TIMING. WHEN TIMING IS ACCEPTABLE, RECHECK CURB IDLE RPM. IF ENGINE RPM IS NOT AT OR BELOW THE CURB IDLE RPM SHOWN ON THE LABEL, RESET ENGINE RPM AND RECHECK TIMING. REPEAT ABOVE UNTIL BOTH ENGINE RPM AND TIMING ARE ACCEPTABLE.

10) REMOVE THE JUMPER WIRE ON THE CARB SWITCH AND RECHECK THE IGNITION TIMING.

11) TURN ENGINE OFF.

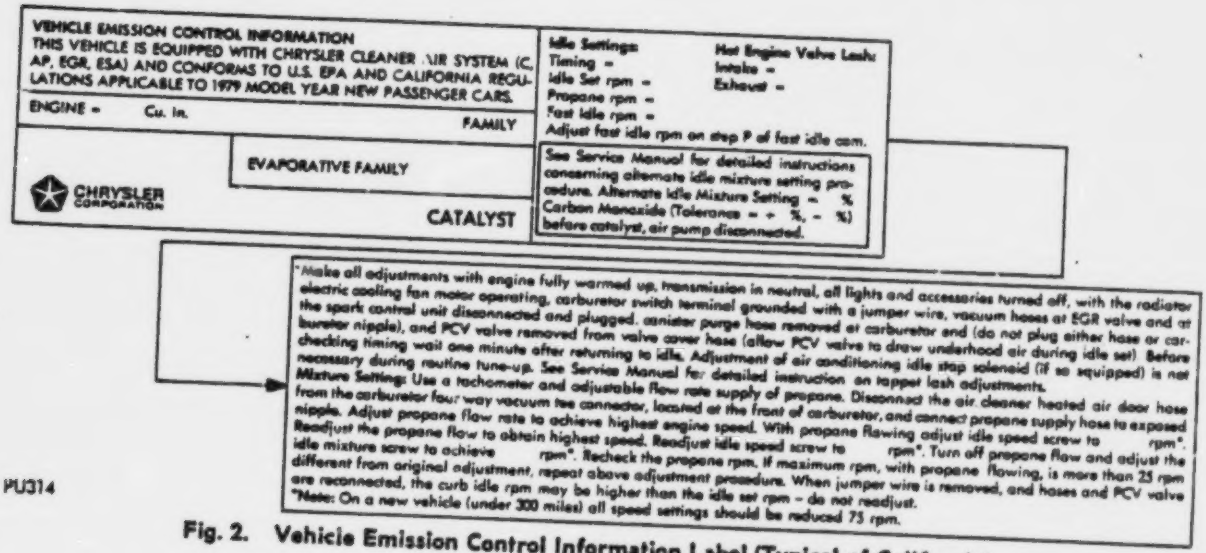
12) REMOVE TIMING LAMP, TACHOMETER ETC.

PROPANE-ASSISTED IDLE SPEED ADJUSTMENT - VEHICLES 1 & 3.

VEHICLES 1+3 use an artificial idle enrichment gas (Propane) to determine the best idle, to conform with Emission Control Specifications. The required items consist of an accurate tachometer, a propane metering valve (Special Tool C-4464) and a container of Propane Gas. (Fig. 4).

Make all adjustments with engine fully warmed up, radiator fan operating, transmission in neutral, headlights off, air conditioning compressor not operating, idle stop carburetor switch (if so equipped) grounded with a jumper wire (Fig. 8) and the vacuum hose at EGR valve (if so equipped) and distributor or spark control unit disconnected and plugged. Disconnect the canister purge hose at the carburetor end (do not plug either hose or carburetor nipple). Remove PCV valve hose from valve cover (allow PCV valve to draw underhood air during idle set). On ESC equipped vehicles wait one minute after returning to idle before checking timing.

(1) Place transmission in neutral, and set parking brake. Start vehicle and allow to warm up on the second highest step of the fast idle cam until thermostat is open and radiator becomes hot. If the engine is cold (below 10.0°C) (50°F.), the engine should be warmed up for at least 5 to 10 minutes on the second highest step of the fast idle cam. If the engine is moderately warm (above 10.0°C) (50°F.), the engine should be run


VEHICLE EMISSION CONTROL INFORMATION
THIS VEHICLE IS EQUIPPED WITH CHRYSLER CLEANER AIR SYSTEM (C,
AP, EGR, ESA) AND CONFORMS TO U.S. EPA AND CALIFORNIA REGU-
LATIONS APPLICABLE TO 1979 MODEL YEAR NEW PASSENGER CARS.
ENGINE - Cu. In. FAMILY
EVAPORATIVE FAMILY
CATALYST

Idle Settings:
Timing -
Idle Set rpm -
Propane rpm -
Fast Idle rpm -
Adjust fast idle rpm on step P of fast idle cam.

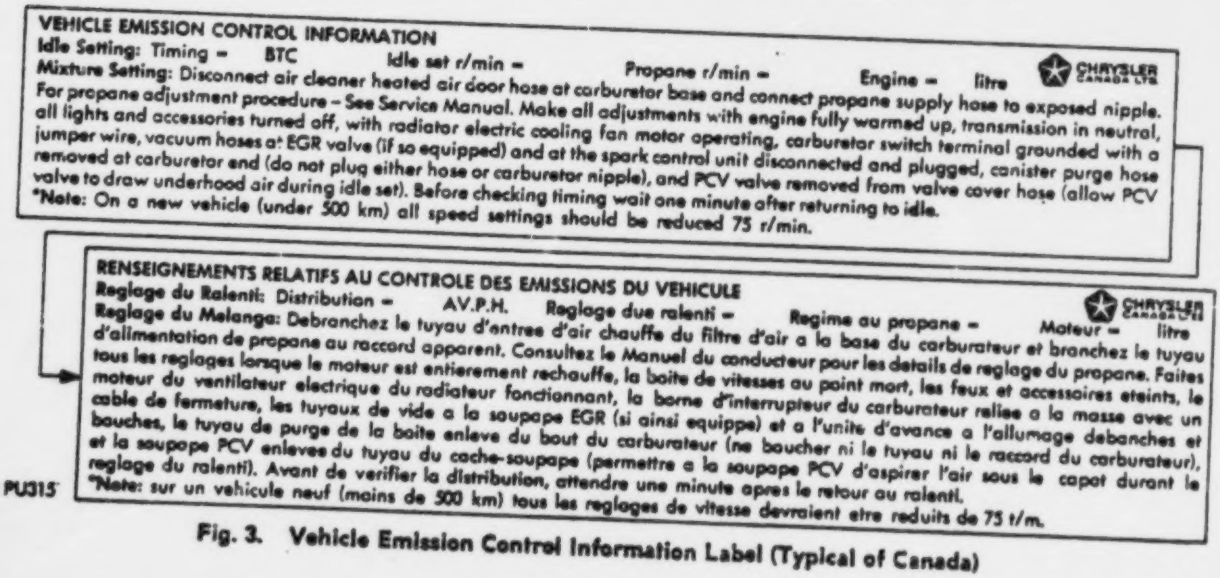
Hot Engine Valve Lash:
Intake -
Exhaust -

See Service Manual for detailed instructions
concerning alternate idle mixture setting pro-
cedure. Alternate Idle Mixture Setting - %
Carbon Monoxide (Tolerance = + %, - %)
before catalyst, air pump disconnected.

*Make all adjustments with engine fully warmed up, transmission in neutral, all lights and accessories turned off, with the radiator
electric cooling fan motor operating, carburetor switch terminal grounded with a jumper wire, vacuum hoses at EGR valve and at
the spark control unit disconnected and plugged. canister purge hose removed at carburetor end (do not plug either hose or car-
buretor nipple), and PCV valve removed from valve cover hose (allow PCV valve to draw underhood air during idle set). Before
checking timing wait one minute after returning to idle. Adjustment of air conditioning idle stop solenoid (if so equipped) is not
necessary during routine tune-up. See Service Manual for detailed instruction on tappet lash adjustments.
Mixture Setting: Use a tachometer and adjustable flow rate supply of propane. Disconnect the air cleaner heated air door hose
from the carburetor four way vacuum tee connector, located at the front of carburetor, and connect propane supply hose to exposed
nipple. Adjust propane flow rate to achieve highest engine speed. With propane flowing adjust idle speed screw to rpm*.
Readjust the propane flow to obtain highest speed. Readjust idle speed screw to rpm*. Turn off propane flow and adjust the
idle mixture screw to achieve rpm*. Recheck the propane rpm. If maximum rpm, with propane flowing, is more than 25 rpm
different from original adjustment, repeat above adjustment procedure. When jumper wire is removed, and hoses and PCV valve
are reconnected, the curb idle rpm may be higher than the idle set rpm - do not readjust.
*Note: On a new vehicle (under 300 miles) all speed settings should be reduced 75 rpm.

PU314

Fig. 2. Vehicle Emission Control Information Label (Typical of California)


VEHICLE EMISSION CONTROL INFORMATION
Idle Setting: Timing - BTC Idle set r/min - Propane r/min - Engine - litre
Mixture Setting: Disconnect air cleaner heated air door hose at carburetor base and connect propane supply hose to exposed nipple.
For propane adjustment procedure - See Service Manual. Make all adjustments with engine fully warmed up, transmission in neutral,
all lights and accessories turned off, with radiator electric cooling fan motor operating, carburetor switch terminal grounded with a
jumper wire, vacuum hoses at EGR valve (if so equipped) and at the spark control unit disconnected and plugged, canister purge hose
removed at carburetor end (do not plug either hose or carburetor nipple), and PCV valve removed from valve cover hose (allow PCV
valve to draw underhood air during idle set). Before checking timing wait one minute after returning to idle.
*Note: On a new vehicle (under 500 km) all speed settings should be reduced 75 r/min.

RENSEIGNEMENTS RELATIFS AU CONTROLE DES EMISSIONS DU VEHICULE
Reglage du Ralenti: Distribution - AV.P.H. Reglage due ralenti - Regime au propane - Moteur - litre
Reglage du Melanga: Debranchez le tuyau d'entree d'air chauffe du filtre d'air a la base du carburateur et branchez le tuyau
d'alimentation de propane au raccord apparent. Consultez le Manuel du conducteur pour les details de reglage du propane. Faites
tous les reglages lorsque le moteur est entierement rechauffe, la boite de vitesses au point mort, les feux et accessoires eteints, le
moteur du ventilateur electrique du radiateur fonctionnant, la borne d'interrupteur du carburateur reliee a la masse avec un
cable de fermeture, les tuyaux de vide a la soupape EGR (si ainsi equippe) et a l'unite d'avance a l'allumage debanches et
bouches, le tuyau de purge de la boite enleve du bout du carburateur (ne boucher ni le tuyau ni le raccord du carburateur),
et la soupape PCV enlevee du tuyau du cache-soupape (permettre a la soupape PCV d'aspirer l'air sous le capot durant le
reglage du ralenti). Avant de verifier la distribution, attendre une minute apres le retour au ralenti.
*Note: sur un vehicule neuf (moins de 500 km) tous les reglages de vitesse devraient etre reduits de 75 t/m.

PU315

Fig. 3. Vehicle Emission Control Information Label (Typical of Canada)

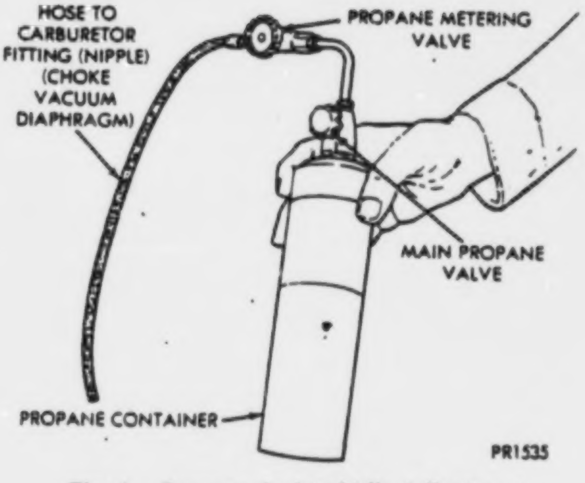

HOSE TO CARBURETOR FITTING (NIPPLE) (CHOKE VACUUM DIAPHRAGM)
PROPANE METERING VALVE
MAIN PROPANE VALVE
PROPANE CONTAINER
PR1535

Fig. 4. Propane Assisted Idle Adjustment Components

on the second highest step of the fast idle cam for at least 2 to 5 minutes.

(2) After the engine is warmed up and running, kick off the fast idle cam. Disconnect air cleaner vacuum supply hose from carburetor. Connect propane supply hose to the nipple. Connect tachometer leads. Open propane supply on-off valve.

On vehicle #3 turn off AIS motor.

(3) Slowly open propane metering valve until maximum engine speed is reached and leave at maximum with propane on. Do not touch the metering valve until the throttle blades are properly set.

NOTE: Too much propane will begin to reduce engine idle speed. (The propane bottle must stand upright to maintain a near constant flow.)

(4) Vehicle #3:

Turn on AIS motor and let engine speed stabilize. Turn off AIS motor and go to step 5.

Vehicle #1:

With propane flowing, adjust idle speed screw on top of the idle stop solenoid until the tachometer indicates (Figs. 6 or 7) the enriched RPM SHOWN ON SPECIFICATION SHEET. Readjust propane control for maximum engine speed, if required. Do not reset this screw once the proper enriched speed has been obtained.

(5) Turn off propane flow and adjust idle mixture screw (Fig. 9) to achieve smoothest idle at curb RPM

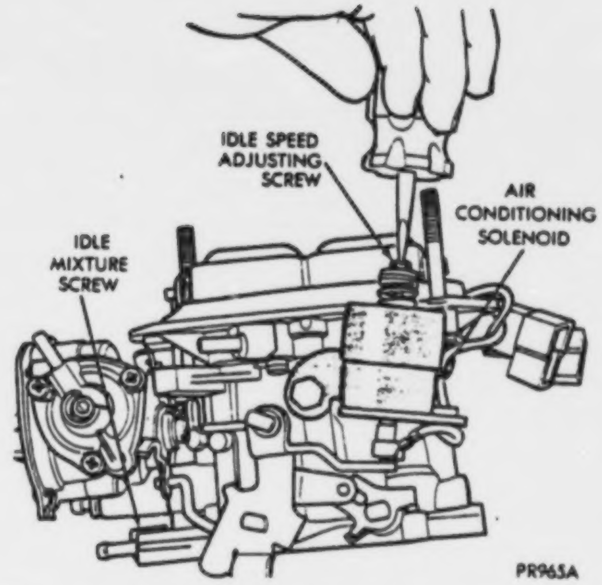

IDLE SPEED ADJUSTING SCREW
AIR CONDITIONING SOLENOID
IDLE MIXTURE SCREW
PR965A

Fig. 6. Propane Assisted Idle Speed and Mixture Adjustment (with air conditioning)

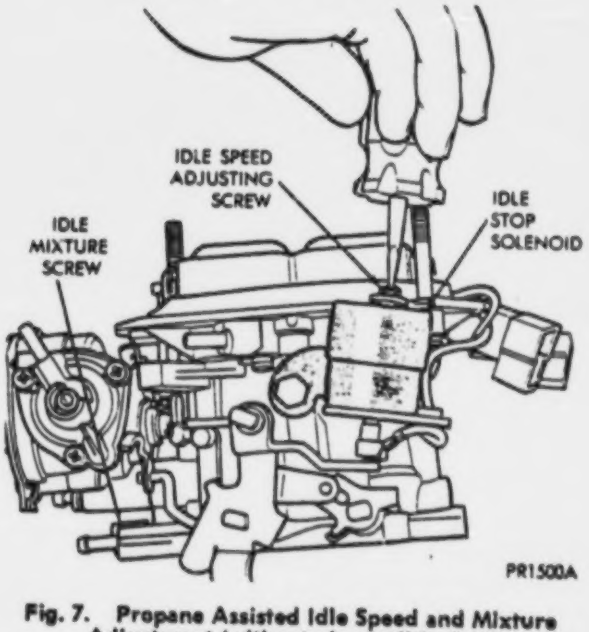

IDLE SPEED ADJUSTING SCREW
IDLE STOP SOLENOID
IDLE MIXTURE SCREW
PR1500A

Fig. 7. Propane Assisted Idle Speed and Mixture Adjustment (without air conditioning)

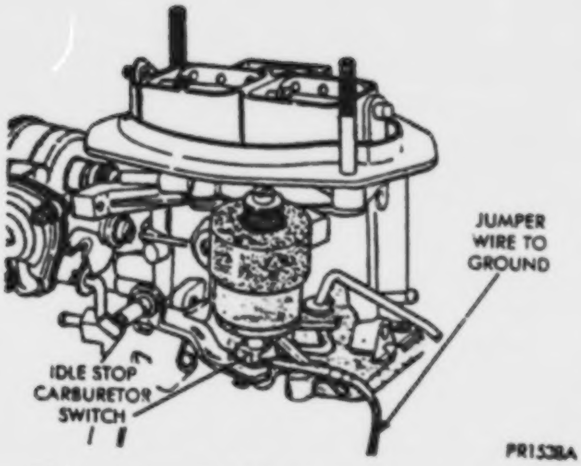

JUMPER WIRE TO GROUND
IDLE STOP CARBURETOR SWITCH
PR1538A

Fig. 8. Grounding Idle Stop Carburetor Switch

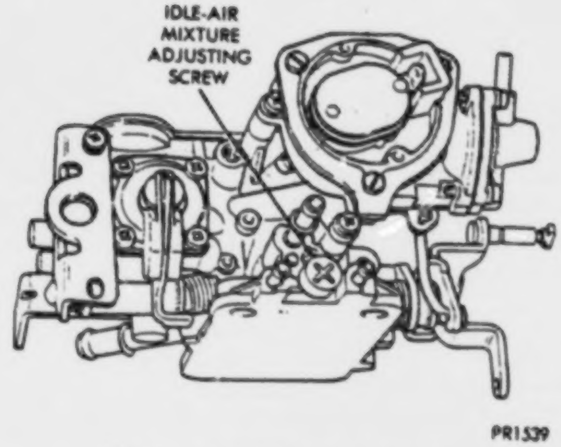

IDLE-AIR MIXTURE ADJUSTING SCREW
PR1539

Fig. 9. Idle Air Mixture Screw

shown on SPECIFICATION SHEET.

(6) Turn on propane again and check maximum speed to see if the idle set has been disturbed. If maximum speed is more than 25 RPM different than the enriched RPM specified on the SPECIFICATION SHEET, repeat steps 4 through 6.

(7) Turn off propane metering valve and remove propane source.

(8) Reinstall the air cleaner or choke diaphragm vacuum supply hose on carburetor.

(9) Connect purge hose and PCV valve, vacuum hose at EGR valve, vacuum hose to ESC unit and remove ground wire from idle stop carburetor switch. Engine RPM may increase, but DO NOT READJUST.

(10) Vehicle #3:

Turn on AIS motor.
Shut off engine.
Re-install appropriate test prom.

PROCEDURE: ADJUSTING HOT FAST IDLE SPEED

- VEHICLES 1 & 3.

1) REMOVE AIR CLEANER TOP.
2) ELIMINATE EGR SIGNAL.
3) DISCONNECT VACUUM LINE TO SPARK CONTROL COMPUTER AT CONVENIENT JUNCTION IN THE ENGINE COMPARTMENT. PLUG CARBURETOR END OF VACUUM LINE. DO NOT PLUG VACUUM LINE TO COMPUTER.
4) REMOVE PCV VALVE FROM MOLDED RUBBER CONNECTOR AND ALLOW TO DRAW UNDERHOOD AIR.
5) DISCONNECT THE CANNISTER PURGE HOSE AT THE CARBURETOR END (DO NOT PLUG EITHER HOSE OR CARBURETOR NIPPLE).
6) ON VEHICLES EQUIPPED WITH A CARBURETOR SWITCH CONNECT A JUMPER WIRE BETWEEN THE CARBURETOR SWITCH AND GROUND.

(6) Disconnect engine cooling fan at radiator and complete circuit at plug with jumper wire to energize fan.

CAUTION: A short to ground will damage wiring system.

(7) Set brake, place transmission in NEUTRAL with engine off, open throttle slightly and place slowest speed step of fast idle cam under adjusting screw. Note that spring forces which influence both fast idle cam and choke valve position are unique to this carburetor. Also, this is only system to use slowest step.

(8) Start engine and determine stabilized speed. Choke valve must be fully open. If speed continues to rise slowly, the idle stop switch has not been grounded properly.

(9) Adjust to specification by turning speed screw. Do not adjust with screw contacting plastic cam. Reposition screw on cam after each adjustment to provide correct throttle closing torque and screw position.

THROTTLE STOP SPEED ADJUSTMENT (WITHOUT AIR CONDITIONING) (FIGURE 46) - VEHICLE 1 -

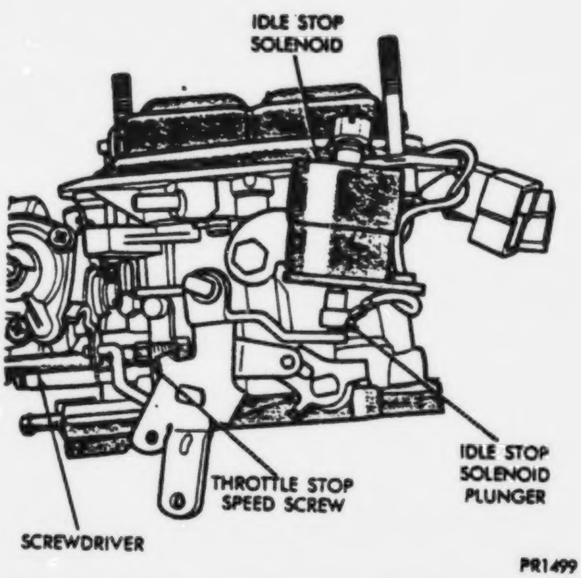

IDLE STOP SOLENOID
IDLE STOP SOLENOID PLUNGER
THROTTLE STOP SPEED SCREW
SCREWDRIVER
PR1499

Fig. 46. Throttle Stop Speed Adjustment (Without Air Conditioning)

(1) Make all adjustments with engine fully warmed up.

(2) Place transmission in neutral and set parking brake.

(3) Headlights off.

(4) Using a jumper wire, ground the idle stop carburetor switch.

(5) Disconnect idle stop solenoid wire at connector.

(6) Adjust throttle stop speed screw to SPECIFICATION

(7) Reconnect idle stop solenoid wire at connector.

(8) Remove jumper wire from the idle stop carburetor switch.

CHOKE VACUUM KICK ADJUSTMENT - VEHICLES 1 & 3.

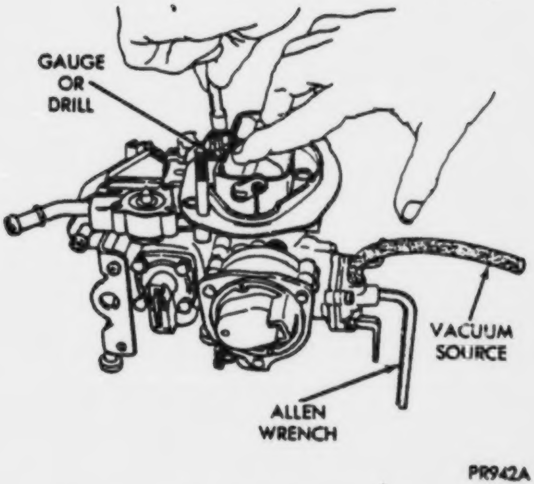


Fig. 41. Adjusting Choke Vacuum Kick

(1) Refer to Fig. 41. Open throttle, close choke then close throttle to trap fast idle system at closed choke condition.

(2) Disconnect vacuum hose from carburetor and replace with hose from auxiliary vacuum source. Apply a vacuum of −51kPa (15 or more inches of mercury).

(3) Apply sufficient closing force to position choke valve at smallest opening possible without distorting linkage system. Note, an internal spring will compress to a stop inside choke system.

(4) Measure by inserting drill or gauge in center of area between top of choke valve and air horn wall at primary throttle end of carburetor. See Specifications above for drill or gauge size to be used.

(5) Adjust by rotating allen head screw in center of diaphragm housing.

(6) Replace vacuum hose on carburetor fitting.

TUNE-UP PROCEDURES - VEHICLE #9

1) Engine fully warmed up.

2) Record - Barometer Pressure (kPa).

3) Disconnect vacuum line to spark control computer at convenient junction in the engine compartment. Plug carburetor end of vacuum line. Do not plug vacuum line to computer.

4) Fan on.

5) Set fast idle switch to "AUTO".

6) Accessories off, lights off.

7) If engine rpm is at or below 1000 prm proceed to next step. If it is higher set idle to 1000 rpm (idle speed screw behind solenoid). Report if speed was high.

8) Set basic timing to specification.

9) Set fast idle to specification* (fast idle speed screw on top of solenoid).

10) Connect ESA vacuum line.

11) Set curb idle to specifications.

12) Remove PCV valve.

13) Adjust idle CO to 1.0%.

14) Reinstall PCV valve.

15) Recheck idle speed. If not to specification, repeat steps 11 to 15.

16) Check idle timing with ESA vacuum connected, (Tolerance 32° ± 2°). Report if out of spec.

* Set switch to "Manual" on instrument panel. Reset to "AUTO" after fast idle adjustment.

APPENDIX C

Cold Weather Program Scheduled Test Vehicle Maintenance Operations and Record

COLD WEATHER PROGRAM

Test Vehicle Maintenance Record

Vehicle I.D.__________ Date ______________ Time_________ Odometer_________

Reason ____

____

SERVICE OPERATIONS	YES	NO	
Engine Oil Filter Changed	☐	☐	
Engine Oil Changed	☐	☐	_____ℓ of 10W30
Spark Plugs Changed	☐	☐	Gap 0.035"

SPECIFICATIONS AND ADJUSTMENTS

	Transmission Dr.	Transmission N	Manufacturer's Specification*	Before adjust.	After Adjust.
Ignition Timing		X			
Idle RPM		X			
Idle Mixture (CO%)		X			
HC ppm		X			
Enriched RPM		X			
Hot Fast Idle RPM		X			
Throttle Stop Speed RPM		X			
Vacuum Kick					
Choke Index					
Fast Idle Cam index					

* See Vehicle Maintenance Specification Sheets

OPERATIONAL CHECKS	O.K.	Not O.K.	Remedial Action
Spark Plugs			
High Tension Wires			
EGR System			
AIR System			
Exhaust System Leaks			
Heated Inlet Air System			
Fuel System Leaks			
Throttle Free			
Brake Drag			
VISUAL CHECKS			
Engine Oil Level			
Trans Fluid Level			
Coolant Level			
Coolant Freezing Temp			
Battery Level			
Battery SG			
Belt Tightness			
Tire Condition			
Air Filter Cond			
Hoses, No. Leaks			

Other Maintenance:____

____

____
Technician

____
Project Engineer

R-8716 (012077)
(Rev. A) 042478

ROAD LOAD POWER CONTROL

FACTORY CALIBRATION PROCEDURE

CALIBRATION SEQUENCE:

A. Preliminary Set Up, Checks and Adjustment
B. EVW Selector Switch Range Verification
C. Board 7 - Thumbwheel Calibration
D. Board 6 - Pulser Calibration
E. Board 7 - Exponent Calibration
F. Board 8 - Horsepower Calibration
G. Board 5 - Analog Timer
H. Board 4 - Digital Timer
I. Board 8 - Rear Roll Speed Calibration
J. Board 7 - Front Roll Speed Calibration
K. Digital Speed Readout Calibration
L. Torque Load Cell Calibration
M. Digital Power Readout Calibration
N. Horsepower Scaling Verification
O. Horsepower "Cal Check" Operation
P. Deadband Adjustment
Q. Thumbwheel Adjustment
R. High Rate Deadband Adjustment
S. Driver Cutoff Adjustment
T. Exponent Verification
U. Load Control Speed Cutoff Verification
V. Manual Load Control Verification
W. Front-Rear/Vehicle Factor Verification
X. Horsepower Index Computer Interface Verification
Y. Final Preparations

A. Preliminary Set-Up, Checks and Adjustments:

1. Connect RLPC to "Dyno Simulator" (Simulator not connected to 115 VAC).
    - a) Digital Instrument Box to Terminals 5, 6 and GND on Simulator.
    - b) RLPC 6 TB, Terminals "H," "N" and GND.
    - c) RLPC 1 TB, Terminals 201, 202, 206, 207, 208, 209, 210 and 211.
    - d) RLPC 5 TB, Terminals 6, 93, 96, 97, 98 and "X."
    - e) Digital Meter Box to RLPC 2 TB, Terminals 301, 302, 303 and 304.
2. Push down RLPC interlock switch.
3. Mode Selector Switch to "Pendant."
4. Speed-Power Switch to "Front."
5. Thumbwheel to 00.0 - Vehicle Factor to 0.00.
6. Turn Simulator RLPC 115 VAC Switch to "OFF."
7. Plug Simulator into 115 VAC.
8. Turn Simulator Digital Meter 115 VAC Switch to "ON."
9. Pot 1, Board 2 - Center.
10. Pot 2, Board 2 - Carefully center and seal.
11. Pot 3, Board 2 - Center.
12. Pot 1, Board 3 - Center.
13. Pot 2, Board 3 - Full CCW.
14. Pots 1 and 2, Board 4 - Full CCW.
15. Pot 3, Board 4 - Full CW.
16. Pots 1 and 2, Board 6 - Center.
17. Pot 3, Board 6 - Full CCW and seal.
18. Pots 4 and 5, Board 6 - Center.
19. Pot 6, Board 6 - Full CCW.
20. Pot 7, Board 6 - Full CCW and seal.
21. Pots 1, 2, 3, 4 and 5, Board 7 - Center.

22. IMPORTANT = Pot 9 (side pot), Board 7 - (Set for 52) - This is a 15-turn pot.

23. Turn all Cal Switches to "RUN" (toward the board).

24. Verify that all interconnect wiring is connected to RLPC terminal blocks properly:

    a) Upper Panel to Hat Section.
    b) EVW Selector Switch to 8 TB.
    c) Interlock Switch to 5 TB and 8 TB.
    d) Ground post to 5 TB.
    e) RLPC to Simulator.
    f) Digital Box to RLPC.
    g) Pendant to 5 TB.

25. Connect DVM (-) lead to RLPC "Common" terminal and leave connected for remainder of test. All following reference to DVM connection refers to (+) lead.

26. Turn Simulator RLPC 115 VAC switch to "ON" and pull RLPC interlock swtich "UP."

27. Check for (+) 15 VDC, ± 0.25 VDC, and (-) 15 VDC, ± 0.25 VDC, with DVM on Board 1 heat sink screws - if not within tolerance turn 115 VAC off and troubleshoot. Also check for ± 5.7 VDC on pins H and F on Board 1. Check for - 9.0 VDC on Terminal 312. Check for + 11.7 VDC on Terminal 207.

28. DVM to Test Point (TP) 5, Board 7.

29. Adjust Pot 6, Board 7, for 0.000 VDC, ± 0.002 VDC.

30. DVM to TP 2, Board 8.

31. Adjust Pot 3, Board 8, for 0.000 VDC, ± 0.002 VDC.

32. DVM to TP 1, Board 8.

33. Adjust Pot 1, Board 8 for 0.000 VDC, ± 0.002 VDC.

B. EVW Selector Switch Verification:

1. Verify that Range Light is on only in the range specified by the "A" number and is out when under or over range.

C. Board 7 - Thumbwheel Calibration:

PANEL SETUP

Thumbwheel - 00.0
All Switches to Run
Power Speed - Front
Mode - Pendant
Vehicle Factor - 00.

1. DVM to Terminal 312, 2 TB.
2. Adjust Pot 1, Board 1, for (-) 9.000 VDC exactly.
3. DVM to TP 1, Board 7.
4. Adjust Pot 1, Board 7, for 0.000 VDC exactly.
5. DVM to TP2, Board 7.
6. Adjust Pot 2, Board 7, for 0.000 VDC exactly.
7. DVM to TP 3, Board 7.
8. Adjust Pot 3, Board 7, for 0.000 VDC exactly.
9. DVM to TP 4, Board 7.
10. Adjust Pot 1, Board 7, for 0.000 VDC exactly.
11. Verify exactly (-) 9.000 VDC on Terminal 312, 2 TB - if not, readjust Pot 1, Board 1, to correct.
12. DVM to TP 4, Board 7.
13. Thumbwheel to 00.9.
14. Adjust Pot 5, Board 7, for (+) 0.0900 VDC.
15. Verify that all positions of the 00.1 thumbwheel read corresponding VDC ± 0.0001 - Example, 00.6 thumbwheel position should read (+) 0.0600 VDC ± 0.0001.
16. Thumbwheel to 09.0.
17. Adjust Pot 4, Board7, for (+) 0.900 VDC.
18. Verify that all of the 01.0 thumbwheel positions read corresponding VDC ± 0.001 - example, 07.0 should read (+) 0.700 ± 0.001.
19. Thumbwheel to 10.0 DVM should read (+) 1.000 VDC ± .001.
20. Thumbwheel to 20.0 DVM should read (+) 2.000 VDC ± .001.

21. Thumbwheel to 30.0 DVM should read (+) 3.000 VDC ± 0.001.

22. Seal Pots 2, 3, 4 and 5, Board 7.

D. Board 6 - Pulser Calibration:

PANEL SETUP

Thumbwheel - 30.0
All switches to R
Power Speed - F
Mode - Pendant
Vehicle Factor

1. Connect Scope to "Common" of RLPC and

   TP 2, Board 6

   Scope set up Volts/CM = 5.0 Volts

   Time/CM = 0.1 Sec

2. Plug Simulator "Pulse Timer" probe into scope.

3. Press reset button on "Pulse Timer" - after timer stops counting (10 secs.), note pulse rate indicator.

4. Adjust Pot 4, Board 6, and repeat steps 3 and 4 until pulse rate is 22 to 25 pulses per 10 secons.

   CCW increases rate

   CW decreases rate

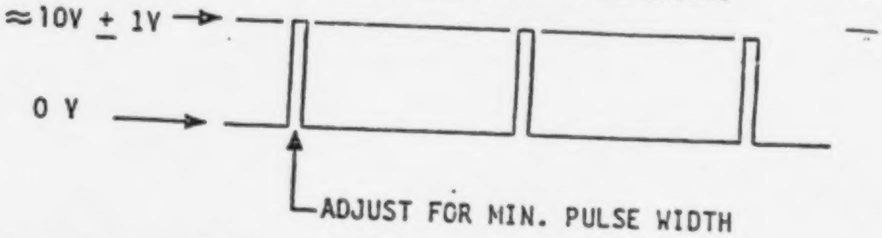
5. Recheck steps 3 through 5 - if within tolerance, seal Pot 4, Board 6.

6. Scope to TP 3, Board 6.

7. DVM to TP 1, Board 8.

8. Adjust Pot 1, Board 8, for DVM reading (+) 0.190 VDC ± 0.005.

9. Adjust Pot 1, Board 6, for scope pattern as shown.



10. Recheck steps 6 through 9 - if readjustment is unneccessary.

11. Adjust Pot 1, Board 8, for DVM reading of (+) 0.595 VDC, ± 0.005.

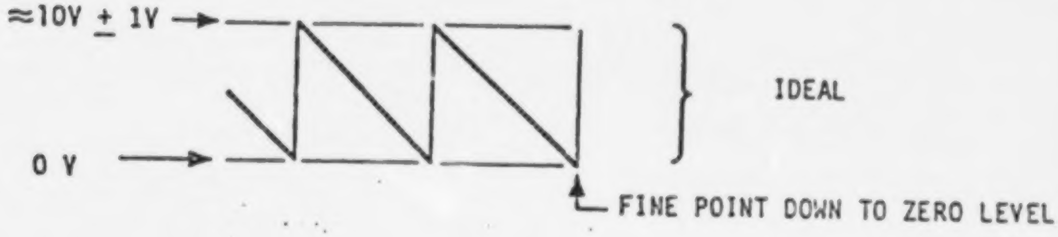
12. Slowly adjust Pot 6, Board 6, until square wave on scope JUST switches to a saw tooth.

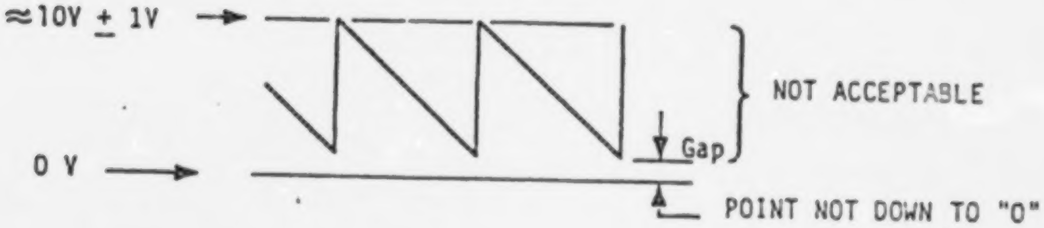
13. Adjust Pot 1, Board 8, for DVM reading of (+) 0.500 VDC, ± 0.010.

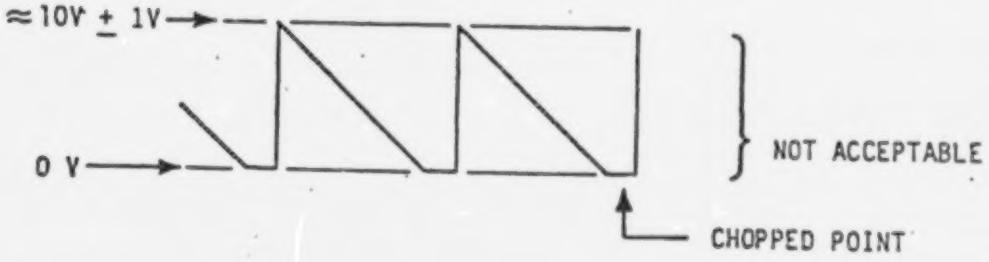
14. Slowly adjust Pot 1, Board 8, CCW until square wave JUSTswitches to a saw tooth - DVM reading should be (=) 0.595 VDC, ± 0.005 - if not, repeat steps 11 through 14.

15. Using "Pulse Timer" adjust Pot 5, Board 6, until saw tooth pulse rate is 22 to 25 pulses in 10 seconds.

16. Adjust Pot 2, Board 6, for a scope wave shape shown below as "IDEAL."


≈10V ± 1V
0 V
IDEAL
FINE POINT DOWN TO ZERO LEVEL


≈10V ± 1V
0 V
NOT ACCEPTABLE
Gap
POINT NOT DOWN TO "O"


≈10V ± 1V
0 V
NOT ACCEPTABLE
CHOPPED POINT

17. Seal Pot 2. Board 6.

18. Adjust Pot 1, Board 8, for 0.00 on DVM.

E. Exponent Calibration:

PANEL SETUP

Thumbwheel - 39.9
All Switches to Cal
Power Speed - Front
Mode - Pendant
Vehicle Factor - 0.

1. DVM to TP 5, Board 7.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 6.000 VDC.
3. DVM to TP 6, Board 7.
4. Note and record DVM reading
5. DVM to TP 5, Board 7.
6. Adjust Pot 5, Board 8, for DVM reading of (+) 2.500 VDC.
7. DVM to TP 6, Board 7.
8. Note DVM reading.
9. DVM reading should be $\frac{(25)^2}{(60)}$ = .1736 X DVM reading recorded in Step 4.
10. Adjust Pot 9, Board 7 (side pot), to a DVM reading .005 higher than the required DVM reading of step 9 and the DVM reading noted in step 8 - read below note before making any adjust of Pot 9.

    NOTE: If the DVM reading noted in step 8 is HIGH, turn Pot 9 CW; if LOW Pot 9 CCW.

    If the difference between the DVM reading of step 8 and the required reading of step 9 is 0.002 or less, adjust Pot 9 to the required reading of step 9.

11: Repeat steps 1 through 12 until the DVM reading noted in step 8 is equal to the required reading of step 9 ± 0.003 VDC without any adjustment of Pot 9.

12. Repeat steps 1 through 5.
13. Adjust Pot 5, Board 8, for DVM reading of + 5.00 VDC.
14. DVM to TP 6, Board 7.

15. DVM reading should be $\left(\frac{50}{60}\right)^2$ = .69444 X DVM reading of step 4 ± 0.002 VDC.

NOTE: If the noted reading is not within the 0.003 tolerance, repeat complete calibration of the Exponent and correct as necessary - if calibration does not correct the error, advise Engineering.

F. Board 8 - Horsepower Calibration:

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 5.000 VDC.
3. DVM to TP 1, Board 8.
4. Adjust Pot 6, Board 8, for DVM reading of (+) 5.000 VDC.
5. DVM to TP 4, Board 8.
6. Adjust Pot 7, Board 8, for DVM reading of (+) 2.500 VDC ± 0.001.
7. Recheck complete calibration correcting as necessary.
8. When calibration is within tolerance, seal Pot 7, Board 8.

PANEL SETUP

Thumbwheel - 39.9
Switches to Cal
Power Speed - Fron
Mode - Pendant
Vehicle Factor - 0

G. Board 5 - Analog Timer:

1. DVM to TP 2, Board 5
2. Note DVM reading - should be between (+) 1.00 and (+) 1.10 VDC - if not, recheck "Thumbwheel" calibration - [illegible]

   RECORD NOTED DVM READING
3. Thumbwheel setting 37.0.
4. Note DVM reading - should be between (+) 5.5 and (+) 5.6 VDC - if not, recheck "Thumbwheel" calibration -

   RECORD NOTED DVM READING [illegible]

PANEL SETUP

Thumbwheel - 07.0
All Switches to Ca
Power Speed - Fron
Model - Pendant
Vehicle Factor - 0

5. Thumbwheel setting 07.0.
6. DVM to TP 6, Board 5.
7. Adjust Pot 2, Board 5, for DVM reading recorded at step 2 excetp (-) VDC.
8. Thumbwheel setting 37.0.
9. Adjust Pot 1, Board 5, for DVM reading recorded at step 4 except (-) VDC.
10. Recheck stpes 5 through 10 as many times as required, readjusting as necessary, until the required (-) VDC readings of step 7 (07.0 Thumbwheel) and step 9 (37.0 Thumbwheel) are obtained without further adjustments of Pots 1 and 2 when Thumbwheel is changed from one setting to the other.
11. Sel Pots 1 and 2, Board 5.
12. Compute the DVM readings recorded at steps 2 and 4 per the following: $-\sqrt{(10)\ \text{DVM reading}}$
    (this will always be a (-) VDC).
    Record the computed VDC.
13. DVM to TP 3, Board 5.
14. Thumbwheel setting 07.0.
15. Adjust Pot 4, Board 5, for DVM reading computed at step 12 for recorded DVM reading of step 2 - Tolerance ± 0.003 VDC.
16. Thumbwheel setting 37.0.
17. Adjust Pot 3, Board 5, for DVM reading computed at step 12 for recorded DVM reading of step 4 - Tolerance ± 0.003 VDC.
18. Set Thumbwheel back and forth at 07.0 to 37.0 as many times as necessary making the adjustments of step 15 for 0.70 setting and step 20 for 37.0 setting until computed VDC is obtained without adjustment at either setting.

19. DVM to TP 5, Board 5.
20. Repeat steps 14 through 18 EXCEPT
    a) Use Pot 6 instead of Pot 4 in step 15.
    b) Use Pot 7 instead of Pot 3 in step 17.
21. DVM to TP 4, Board 5.
22. Thumbwheel setting 39.0.
23. Adjust Pot 5, Board 5, for DVM reading of 0.000 VDC ± 0.001.
24. DVM to TP 8, Board 5.
25. Adjust Pot 8, Board 5, for DVM reading of 0.000 VDC, ± 0.001.

H. Board 4 - Digital Timer:

PANEL SETUP

Thumbwheel - 5.00
All Switches to Rur
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.

1. Press "Index Light" and while light is flashing, change Thumbwheel to 35.0.
2. "Low Rate Load" light will come on approximately 10 seconds after "Index Light" is pressed - time the duration that load light is on.
3. Adjust Pot 1, Board 4, and repeat steps 1 and 2 until direction of load light is on 6.0 seconds.
   CW increases time.
   CCW decreases time.
4. Thumbwheel to 35.0.
5. Press "Index Light" and while light is flashing, change Thumbwheel to 05.0.
6. "Low Rate Unload" light will come on approximately 10 seconds after "Index Light" is pressed - time the duration that Unload light is on.

7. Adjust Pot 2, Board 4, and repeat steps 4 through 6 until duration of Unload light on is 9.0 seconds.

   CS increases time.

   CCW decreases time.

8. Make random changes of the Thumbwheel setting, increasing and decreasing, large and small changes throughout the range and check for operation of the timer system.
   a) The smaller the change, the shorter the load or unload light duration.
   b) Increase in setting should always turn on load light.
   c) Decrease in setting should always turn on unload light.
   d) Load and unload lights should never both come on.
   e) Duration that load or unload light is on should not exceed 1.0 second when Thumbwheel setting is changed by 01.0.
   f) Load or unload valves should not chatter during "ON" cycle.

9. Press "Index Light" and time duration that Index Light flashes.

10. Adjust Pot 3, Board 4, and repeat step 10 until the "Index Light" flashes for 30 seconds ± 2 seconds.

    CCW increases time.

    CW decreases time.

I. Rear Roll Speed Calibration:

1. DVM to TP 2, Board 8 323 ·4TB

2. With generator motor stopped, adjust t 3, Board 8, to obtain a DVM reading of 0.000 ± .002 VDC.

3. Turn generator motor on.

4. Adjust Pot 4, Board 8, to obtain a DVM reading of (+) ~~4.500~~ 4.652 VDC ± .002.

PANEL SETUP

Thumbwheel - 02.
All Switches to Ru
Mode - Pendant
Speed Power - Re
Vehicle Factor - 0

NOTE: If any correction of the 0.000 reading is required to stay within tolerance, repeat steps 2, 3, 4 and 5.

6. Stop generator motor.

J. Front Roll Speed Calibration:

1. DVM to TP 5, Board 7. 324 ~~2~~ 4 TB
2. With the generator motor stopped, adjust Pot 6, Board 7, to obtain a DVM reading of 0.000 V ± .002 VDC.
3. Start generator motor.
4. Adjust Pot 7, Board 7, to obtain a DVM reading of ~~4.300~~ 4.632 VDC ± 0.002.
5. Stop generator motor and recheck step 2 above.

   NOTE: If any correction of the 0.000 reading is required to stay within tolerance, repeat steps 2, 3, 4 and 5.
6. Stop generator motor.

PANEL SETUP

Thumbwheel - 02.0
All Switches to Run
Power Speed - Front
Mode - Pendant
Vehicle Factor - 0.0

K. Digital Speed Readout Calibration:

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, to obtain a DVM reading of 5.000 V ± .002 VDC.
3. Adjust speed span pot located under the Clayton logo on the instrument box to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter

PANEL SETUP

Thumbwheel - 02.0
All Switches to Cal
Mode - Pendant
Speed Power - Front
Vehicle Factor - 0.0

Thumbwheel - 02.0
All Switches to R
Mode - Pendant
Speed Power - Front
Vehicle Power - 0 0C

1. DVM to TP 4, Board 8, and record DVM Reading including (+) or (-) sign.
2. Set Switch 2, Board 8, to the "Cal"
   1 , board 7,
   position (away from board).
3. Adjust Pot 5, Baord 8, to obtain a 50.0 MPH (80.5 k/hr) reading on the digital speed meter.
4. DVM to TP 1, Board 8.
5. Turn on generator motor to vibrate load cell system.
6. Adjust Pot 1, Board 8, to obtain a DVM reading of + .050 V ± 0.005 VDC.
7. DVM to TP 4, Board 8.
8. Slowly adjust Pot 1, Board 8, clockwise until DVM reading Just reaches the EVM reading recorded in step 1 above.

   CAUTION: Do not turn the pot more than is absolutely necessary to just reach the desired DVM reading.
9. DVM to TP 1, Board 8, and record this reading for use in steps L-14, S-5 and U-7 of the Calibration Procedure.
10. Install deadweight calibration hook and pan onto the torque arm.
11. [redacted] install three35-pound weights onto the hook and pan.
12. Adjust Pot 2, Board 8, to obtain a DVM reading of 4.07 V ± .002 VDC.

14. Compare DVM reading with reading obtained in step 9 - if not the same, within ± 0.002 VDC, adjust Pot 1, Board 8, to correct, and repeat steps 10 through 14. 0.

M. Digital Power Readout Calibration:

PANEL SETUP

Thumbwheel - 02.0
All Switches to Run
Mode - Pendant
Power Speed - Front
Vehicle Factor - 0.(

1. Stop the generator motor.
2. Remove the instrument box cover.
3. Adjust the digital power meter to obtain a reading of 00.0 - adjust screw is accessible through the lower slot on the rear left side of the meter case - replace cover on instrument box.
4. Set Switches 1 and 2, Board 8, to the "Cal" position (away from board). 2 board 7 to cal
5. Adjust Pot 5 on Board 8 to obtain a 50.0 MPH (80.5 k/hr) reading on the digital speed meter. TP 2 Board 8
6. DVM to TP 1, Board 8.
7. Adjust Pot 6, Board 8, to obtain a DVM reading of (+) 4.070 V ± 0.002 VDC.
8. Adjust the power span pot located under the Clayton logo on the instrument box to obtain a reading of 40.7.

N. Horsepower Scaling Verification:

PANEL SETUP

Thumbwheel - 02.0
Sw 2 Bd 8 - Cal
Sw 1 Bd 7 - Run
Mode - Pendant
Power Speed - Front
Vehicle Factor - 0.0

1. Set Switch 1, Board 8, to "Run" position (toward the board).
2. Adjust Pot 5, Board 8, as necessary to obtain a 50.0 MPH (80.5 k/hr) readout on the digital speed meter.
3. Turn on generator motor - place weights on the torque arm and check that horsepower readout is within tolerance of the table following:

None	0.0 ± 0.1 HP
Hook and Pan	1.9 ± 0.1 HP
Hook and Pan + 5 lbs.	14.8 ± 0.1 HP
Hook and Pan + 10 lbs.	27.8 ± 0.1 HP
Hook and Pan + 15 lbs.	40.7 ± 0.1 HP

4. Repeat paragraphs 1 and M as necessary for corrections.

O. Horsepower "Cal Check" Button Calibration:

1. Adjust Pot 5, Board 8, to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter.
2. Press the "Cal Check" button and record the power reading - this reading is the "Cal Check" number - Should be 22.3 + 00.1.

PANEL SETUP

Thumbwheel - 02.0
Sw 1 Bd 8 - Run
Sw 1 Bd 7 - ~~Run~~ Cal
Sw 2 Bd 8 - Cal
Mode - Pendant
Speed Power - Front
Vehicle Factor - 0.

P. Deadband Adjustment:

1. Adjust Pot 5, Board 8, to obtain 50.0 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Board 8, until the digital power meter reads 30.0 HP.
3. Adjust Pot 8, Board 7, until the dead band is centered around 30.0 HP.
4. Adjust Pot 6, Board 8, until all the load and unload lights go out (center of deadband).
5. Adjust Pot 6, Board 8, clockwise until the low rate load light juststarts to pulse - record the power reading.
6. The difference between the readings of 3 and 4 is the deadband.
7. Adjust Pot 3, Board 2, and repeat steps 3 and 4 until the difference between 3 and 4 (deadband) is equal to 0.4 horsepower.

PANEL SETUP

Thumbwheel - 30.0
Sw 1 & 2 Bd 8 to Ca
Sw 1 Bd 7 - Cal
Mode - Thumbwheel
Speed Power - Front
Vehicle Factor - 0.

Q. Thumbwheel Adjustment:

I. THUMBWHEEL - LOW RANGE:

PANEL SETUP

Thumbwheel - 03.0
Sw 1 & 2 Bd 8 to Cal
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.0

1. Adjust Pot 5, Board 8, to obtain a reading of 50 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Board 8, to obtain a reading of 3.0 HP on the digital power meter.
3. Adjust Pot 1, Board 7, until low and high rate load and unload lights go out.
4. Adjust Pot 6, Board 8, counterclockwise until the low unload light *just starts* to pulse - record the power reading.
5. Adjust Pot 6, Board 8, clockwise until the low light *just starts* to pulse - record the power reading.
6. Adjust Pot 1, Board 7, until the difference between 4 and 5 is centered around the 3.0 HP (load light *just starts* to pulse at 2.8 HP and unload light *just starts* to pulse at 3.2 HP).

II. THUMBWHEEL SPAN ADJUSTMENT:

Set "Thumbwheel Span" as follows:

1. DVM to Terminal 312, 2 TB.
2. Adjust Pot 1, Board 1, for DVM reading of (-) 9.000 VDC *exactly*.
3. Set the "Thumbwheel" to read 39.0.
4. Set Switches 1 and 2, Board 8, and Switch 1, Board 7, to the "Cal" position (away from board).
5. Adjust Pot 5, Board 8, to obtain a reading of 50.0 MPH (80.5 k/hr) on the digital speed meter.

digital power meter.

7. Adjust Pot 8, Board 7, until low and high rate load and unload lights go out.
8. Adjust Pot 6, Board 8, counterclockwise until the low unload light just starts to pulse - record power meter reading.
9. Adjust Pot 6, Board 8, clockwise until the low load light just starts to pulse - record power meter reading.
10. Adjust Pot 8, Board 7, until the readings of steps 8 and 9 are equally centered around 39.0 HP (load light just pulses at 38.8 and unload light just pulses at 39.2 HP).
11. IMPORTANT - Repeat parts I and II as many times as necessary until the Thumbwheel can be set for 03.0 and 39.0 and the "deadband" of 00.4 is centered at both settings without any adjustment of Pots 1 or 8, Board 7. Be sure the 50.0 MPH setting is maintained.

F. High Rate Deadband Adjustment:

1. Adjust Pot 5, Board 8, to obtain a reading of 50 MPH (80.5 k/hr) on the digital speed meter.
2. Adjust Pot 6, Baord 8, for a reading of 40.5 on the power meter.
3. Adjust Pot 1, Board 3, until the high rate unload light just comes on.
4. Adjust Pot 6, Board 8, for a reading of 37.5 on the power meter.
5. Adjust Pot 1, Board 2, until the high rate load light just comes on.

PANEL SETUP

Thumbwheel - 39.0
Sw 1 & 2 Bd 8 to Cal
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.

S. Driver Cutoff Adjustment:

1. DVM to TP 1, Board 8.
2. Adjust Pot 1, Board 8, to obtain a DVM reading of + 0.060 V ± .005 VDC.

PANEL SETUP

Thumbwheel - 00.0
Sw 1 & 2 Bd 8 to Run
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.0

unload lights _just_ go out.

4. Turn on generator motor to vibrate load cell system.
5. Adjust Pot 1, Board 8, to obtain the same DVM reading as recorded in paragraph L-9.
6. Turn off generator motor.

T. Exponent Verification:

PANEL SETUP

Thumbwheel - 32.0
Bd 7 & 8 Sw to Cal
Mode - Thumbwheel
Power Switch - Front
Vehicle Factor - 0.0

1. DVM to TP 2, Board 8.
2. Adjust Pot 5, Board 8, for DVM reading of (+) 5.000 VDC ± 0.001.
3. Set Thumbwheel to 32.0
4. Adjust Pot 6, Board 8, for 32.0 HP on digital meter.
5. Using Pot 6, Board 8, check that "Deadband" is 0.40 and is centered about 32.0 - if not, recheck Thumbwheel Calibration, paragraphs Q-I and II, and repeat paragraph T.
6. Reset Pot 6, Board 8, for 32.0 HP on digital meter.
7. Adjust Pot 5, Board 8, for a DVM reading of 2.500 VDC ± 0.001.
8. Horsepower reading should be 16.0 - if not, recheck the Horsepower Calibration, paragraphs L, M and N, and repeat paragraph T.
9. Adjust Pot 6, Board 8, for 4.0 HP on digital meter.
10. Using Pot 6, Board 8, check that "Deadband" is centered about 4.0 HP ± 0.05 and that "Deadband" is less than 00.4 HP (deadband should be approximately 00.2) - if not, recheck Exponent Calibration and repeat paragraph T.
11. If ok, set Thumbwheel to 16.0.
12. Adjust Pot 6, Board 8, for 2 HP, check "Deadband" for 0.2 HP wide.
13. Adjust Pot 6, Board 8, for 8.0 HP on digital meter.
14. Adjust Pot 5, Board 8, for 5.000 VDC. Power Meter should read 16.0 HP.
15. Check "Deadband" at 16 HP, should be 0.4 wide.

U. Load Control Speed Cutoff Verification:

PANEL SETUP

Thumbwheel - 39.0
Sw 1 Bd 8 to Run
Sw 2 Bd 8 to Cal
Sw 1 Bd 7 to Cal
Mode - Thumbwheel
Power Speed - Fron
Vehicle Factor - 0.0

1. DVM to TP 1, Board 8.
2. Adjust Pot 1, Board 8, for (-) 0.050 VDC ± 0.005.
3. Adjust Pot 5, Board 8, for 10 MPH on digital meter - load light should be on.
4. Using Pot 5, Board 8, decrease MPH slowly and note MPH that all load lights go out-- should be between 3 and 5 MPH.
5. Using Pot 5, Board 8, increase MPH slowly and note MPH that load light comes on - should be between 4 and 6 MPH.
6. Turn on generator motor to vibrate load cell system.
7. Adjust Pot 1, Board 8, for same DVM reading recorded in paragraph L-9.
8. Turn off generator motor.

V. Manual Load Control Verification:

PANEL SETUP

Thumbwheel - 00.0
All Switches to Ru
Mode - Pendant
Power Speed - Fron
Vehicle Factor - 0.

1. Bleed valve light of Simulator should be on.
2. Press Pendant unload button and verify that the low rate unload light of the RLPC comes on, and the bleed valve light of the Simulator goes out.
3. Press Pendant load button and verify that the low rate load light of the RLPC comes on, and the bleed valve light of the Simulator goes out.
4. Verify that the bleed valve light is not on when Mode Selector is in the Thumbwheel or Computer position and the Pendant is not functional.

W. Front-Rear/Vehicle Factor Verification:

PANEL SETUP

Thumbwheel - 39.0
Sw 1 Bd 8 to Cal
Sw 2 Bd 8 to Run
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Rear
Vehicle Factor - 0.

1. DVM to TP 1, Board 8.
2. Turn generator motor on.
3. Adjust Pot 6, Board 8, until all load/unload lights are out (this puts control in the center of the deadband).
4. Increase vehicle factor adjustment until high rate load light pulses then turns on full.
5. Turn off motor.

X. Horsepower Index Computer Interface Verification:

PANEL SETUP

Thumbwheel - 30.0
All Switches - Run
Power Speed - "Fro
Mode - "Thumbwheel
Vehicle Factor - 0

1. DVM to Terminal 320 on 3 TB.
2. Note that DVM reads 0.00 VDC.
3. Mode Selector to "Computer."
4. Note that DVM reads + 15 +.25 VDC.
5. Turn Power OFF!
6. Connect Ohmmeter to Terminals 317 and 318.
7. Note that there is continuity.
8. Mode Selector to "Thumbwheel."
9. Note that Ohmmeter reads "Open Circuit."

Y. Final Preparation:

1. Turn RLPC and digital meter 115 VAC OFF at Dynamometer Simulator and unplug Simulator from 115 VAC.
2. Check that all following Pots have been SEALED:

Pot 2	Board 2
Pots 1, 2 and 3	Board 4
Pots 1 through 8	Board 5
Pots 1 through 7	Board 6
Pots 2, 3, 4, 5, 8 and 9	Board 7
Pot 7	Board 8

3. Disconnect Dynamometer Simulator, Scope and DVM from RLPC.
4. Thumbwheel 02.0 - Vehicle factor 0.00 - Speed Power Front - Mode Pendant.
5. Set 7 and 8 Board Switches to "Run."
6. Check to be sure all Terminal Board screws are tight.
7. Secure all covers.

L/sd/JM/J.Asmus/A10-29
042678

DRIVER CUTOFF ADJUSTMENT:

Thumbwheel - 00.0
Sw 1 & 2 Bd 8 to Cal.
Sw 1 Bd 7 to Run
Mode - Thumbwheel
Power Speed - Front
Vehicle Factor - 0.00

1. DVM to TP1, Board 8
2. Adjust Pot 6, Board 8, to obtain a DVM reading of + 0.060 ± .005 VDC
3. Adjust Pot 2, Board 3, until both the low and high rate unload lights just go out
4. Adjust Pot 6, Board 8, for a 30 HP reading on meter

C

APPENDIX E

Basic Electrical (RLPC) Calibration Procedure

TRANSPORT CANADA

CLAYTON EMISSION DYNAMOMETER/RLPC

CALIBRATION CHECK LIST

DYNAMOMETER MODEL: ____________ DATE: __________

SN : ____________

RLPC SN : ____________ TECHNICIAN: ____________

N.B. Allow 30 minutes for electronics to stabilite before proceeding with the calibration

A- LOAD WATER PRESSURE REGULATOR (glycool)

___ 1- Open the P.A.U. drain cock fully
___ 2- Air and water supply on (pump on)
___ 3- Lifts/roll brakes down or off
___ 4- Mode selector switch on control box to pendant
___ 5- While pressing the on button on the control pendant, observe the guage on the water regulator for a reading of 25 psi. Repeat several times to verify guage reading. Adjust if required and secure the lock nut.

Note: Guage reading will be higher with load valve closed.

___ 6- Close PAU drain cock.

B- P.A.U BLEED PORT AIR PRESSURE REGULATOR

___ 1- Air pressure supply on
___ 2- Lifts up or roll-brakes on
___ 3- Observe the guage on the air pressure regulator for a reading of 12 psi. Adjust if required and secure the lock nut.

C- WARM UP

___ 1- Dynamometer with warm up load operated minimum 20 min.
___ 2- Record P.A.U. temperature: ________ ° F
___ 3- Negative lead of DVM to 1 TB common

D- REAR ROLL CALIBRATION

___ 1- Speed/Power switch to: Rear Roll

______ 2- Terminal 201 - T.G. output at 1800 R.P.M.: __________ V.D.C.
______ 3- Positive lead of D.V.M. to terminal 324
______ 4- Adjust pot 3 board 8 to DVM reading of 0.000 ± .002 VDC (rolls stopped)
______ 5- Adjust pot 4 board 8 to DVM reading of 4.630 ± .002 VDC (Rear roll at 1800 R.P.M.) or synthetic value equal to T.G. output at 1800 R.P.M.
______ 6- Recheck pot 3 board 8 reading at 0.00 ± .002 VDC (Rolls stopped)

E- FRONT ROLL CALIBRATION

______ 1- Speed/power switch to: Front roll
______ 2- Terminal 206 - T.G. output at 1800 R.P.M.: __________ VDC
______ 3- Positive lead of DVM to test point 5 board 7
______ 4- Adjust pot 6 board 7 to DVM reading of 0.000 ± .002 VDC (rolls stopped)
______ 5- Adjust pot 7 board 7 to DVM reading of 4.630 ± .002 VDC (Front roll at 1800 R.P.M.) or synthetic value equal to T.G. output at 1800 R.P.M.
______ 6- Recheck pot 6 board 7 reading at 0.000 ± .002 VDC (Rolls stopped)

F- DIGITAL SPEED READOUT CALIBRATION

______ 1- Positive lead of DVM to test point 2 board 8
______ 2- Speed/power switch to: Front roll
______ 3- Switch 2 board 8 to: CAL (away from board)
______ 4- Switch 1 board 7 to: CAL (" " ")
______ 5- Adjust pot 5 board 8 to DVM reading of 5.000 ± .002 VDC
______ 6- Adjust span pot under logo on inst. box to 50.0 M.P.H. on digital speed meter

G- TORQUE CELL CALIBRATION

______ 1- Remove vehicle - lower lift - release brakes - remove calibration arbor
______ 2- Switches 1 & 2 board 8 & switch 1 board 7 to: Run (toward board)
______ 3- Positive lead of DVM to test point 4 board 8 reading (including + or - sign): ______________ V.D.C.
______ 4- Switch 2 board 8 & switch 1 board 7 to: CAL
______ 5- Adjust pot 5 board 8 to: 50 MPH reading on digital speed meter
______ 6- Positive lead of DVM to test point 1 board 8
______ 7- Remove load cell hysteresis (gently tap the load cell mounting channel)
______ 8- Adjust pot 1 board 8 to DVM reading of 0.060 ± .005 VDC
______ 9- Positive lead of DVM to test point 4 board 8
______ 10- Adjust pot 1 board 8 clockwise until DVM reading just equals reading at 3: ____________ V.D.C.

_____ 11- Positive lead of DVM to test point 1 board 8 reading (include + or - sign): __________ V.D.C.
_____ 12- Install arbor D33102 & tighten retaining screw to snug
_____ 13- Gently install (3) D33112 weights - remove hysteresis
_____ 14- Adjust pot 2 board 8 to DVM reading of 4.070 ± .002 V.D.C.
_____ 15- Remove weights and arbor - remove hysteresis
_____ 16- Compare DVM reading with reading in 11 within ± 0.002 VDC __________ VDC
_____ 17- Adjust pot 1 board 8 to correct & repeat step 11 through 16

H- DIGITAL POWER READOUT CALIBRATION

_____ 1- Adjust power meter reading to: 00.0 H.P. (remove front glass of the digital unit) (Both in case of 2 units) or (Remove instrument box cover)
_____ 2- Replace glasses or cover
_____ 3- Switches 1 & 2 board 8 and switch 1 board 7 to: CAL
_____ 4- Adjust pot 5 board 8 to: 50 MPH (on digital speed meter)
_____ 5- Positive lead of DVM to test point 1 board 8
6- Adjust pot 6 board 8 to DVM reading of 4.070 ± .002 VDC
7- Adjust power span pot for reading of: 40.7 H.P. (located under Clayton logo)

I- HORSE POWER SCALING VERIFICATION

_____ 1- Switch 1 board 8 to: RUN (toward board)
_____ 2- Switch 2 board 8 and 1 board 7 to: CAL
_____ 3- Adjust pot 5 board 8 to: 50 MPH (on digital speed meter)
_____ 4- Install as followed arbor & weighs and verify reading (vibrate after each wt.)

None: 00.0 ± 0.1 H.P. __________ H.P.

Arbor: 01.9 ± 0.1 H.P. __________ H.P.

Arbor + 35 pounds: 14.8 ± 0.1 H.P. __________ H.P.

Arbor + 70 pounds: 27.8 ± 0.1 H.P. __________ H.P.

Arbor + 105 pounds: 40.7 ± 0.1 H.P. __________ H.P.

_____ 5- If not within tolerance steps G & H repeated to correct

J- HORSE POWER "CAL CHECK" CALIBRATION

_____ 1- Warm up dynamometer for minimum 10 minutes
P.A.U.: __________ °F
_____ 2- Set mode selector switch to: Pendant
_____ 3- Switch 2 board 8 & switch 1 board 7 to: CAL (Away form board)
_____ 4- Switch 1 board 8 to: RUN (Toward board)
_____ 5- Adjust pot 5 board 8 to: 50.0 MPH reading on digital speed meter

______ 6- Remove vehicle - lower lifts - release brakes
______ 7- Remove load cell hysteresis
______ 8- Press CAL button and record H.P. on digital meter
Reading: __________ H.P.

K- DEADBAND ADJUSTMENT

______ 1- Turn water supply to dynamometer off (or switch off the pump)
______ 2- Speed/power switch to: Front roll
______ 3- Set thumbwheel to: 30.0 H.P.
______ 4- Set mode selector to: thumbwheel
______ 5- Set vehicle factor to: 0.00
______ 6- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL
______ 7- Adjust pot 5 board 8 to: 50MPH reading on digital speed meter
______ 8- Positive lead of DVM to terminal 312: __________ VDC
______ 9- Adjust pot 1 board 1 for -9.000 ± .002 VDC
______10- Adjust pot 6 board 8 to just start low rate unload light pulse
Reading: __________ H.P.
______11- Adjust pot 6 board 8 to just start low rate load light pulse
Reading: __________ H.P.
______12- Difference between 10 & 11: __________ H.P. This is the high deadband
______13- Adjust pot 3 board 2 and repeat 10 & 11 until high deadband equals 0.4 H.P.

L- THUMBWHEEL "LOW RANGE" ADJUSTMENT

______ 1- Set thumbwheel to: 03.0 H.P.
______ 2- Set mode selector to: thumbwheel
______ 3- Set vehicle factor to: 0.00
______ 4- Switches 1 & 2 board 8 and switch 1 board 7 to: CAL
______ 5- Adjust pot 5 board 8 to: 50.0 MPH reading on digital speed meter
______ 6- Adjust pot 6 board 8 to: 3.0 H.P. reading on digital power meter
______ 7- Adjust pot 1 board 7 until low & high rate load & unload lights go out
______ 8- Adjust pot 6 board 8 counter clockwise to just start low rate unload light pulse
Reading: __________ H.P.
______ 9- Adjust pot 6 board 8 clockwise to just start low rate load light pulse
Reading: __________ H.P.
______10- Difference between 8 & 9 is: __________ H.P. This is the low deadband
______11- Adjust pot 1 board 7 to center deadband around 3.0 H.P. - (3.2/2.8)

M- THUMBWHEEL "SPAN" ADJUSTMENT

______ 1- Set thumbwheel to: 39.0 H.P.
______ 2- Set mode selector to: thumbwheel
______ 3- Set vehicle factor to: 0.00
______ 4- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL

_____ 5- Adjust pot 5 board 8 to: 50MPH on digital speed meter
_____ 6- Adjust pot 6 board 8 to: 39.0 H.P. on digital power meter
_____ 7- Adjust pot 8 board 7 until low & high rate load/unload lights go out
_____ 8- Adjust pot 6 board 8 counter clockwise to just start low rate unload light pulse   Reading: __________ H.P.
_____ 9- Adjust pot 6 board 8 clockwise to just start low rate load light pulse   Reading: __________ H.P.
_____10- Difference between 8 & 9 is: __________ H.P. This is the thumbwheel span
_____11- Adjust pot 8 board 7 to EXACTLY center around 39.0 H.P. - (39.2/38.8) (Repeat L & M as necessary for correction)

N- HIGH RATE DEADBAND ADJUSTMENT

_____ 1- Set thumbwheel to: 39.0 H.P.
_____ 2- Set mode selector to: THUMBWHEEL
_____ 3- Set vehicle factor to: 0.00
_____ 4- Switches 1 & 2 board 8 & switch 1 board 7 to: CAL
_____ 5- Adjust pot 5 board 8 to: 50 MPH on digital speed meter
_____ 6- Adjust pot 6 board 8 to: 40.5 H.P. on digital power meter
_____ 7- Adjust pot 1 board 3 to just start high rate unload light
_____ 8- Adjust pot 6 board 8 to: 37.5 H.P. on digital power meter
_____ 9- Adjust pot 1 board 2 to just start high rate load light

Note: Any of these adjustments affects items K & L - recheck K & L

_____10- Re-adjust pot 6 board 8 to DVM reading of 4.070 ± .002 VDC as per H   Reading: __________ VDC

O- DRIVER CUT OFF ADJUSTMENT

_____ 1- Set thumbwheel to: 0.00 H.P.
_____ 2- Switches 1 & 2 board 8 & switch 1 board 7 to: RUN
_____ 3- Positive lead of DVM to test point 1 board 8
_____ 4- Adjust pot 1 board 8 to DVM reading of + 0.060 ± .005 VDC
_____ 5- Adjust pot 2 board 3 clockwise to just stop both low & high rate unload lights
_____ 6- Remove hysteresis
_____ 7- Adjust pot 1 board 8 to same reading as recorded in G 11   Reading (include + or - sign): __________ VDC

P- FINAL SYSTEM PREPARATION

_____ 1- Switches 1 & 2 board 8 & switch 1 board 7 to: RUN
_____ 2- Remove DVM leads
_____ 3- Reinstall cover on R.L.P.C.
_____ 4- Return logo on instrument box (es) to horizontal

_____ 5- Turn water supply ON (glycool)

THE SYSTEM IS NOW CALIBRATED AND READY FOR OPERATION.

TECHNICIAN: ______________________

DATE: ______________________

G.P.

APPENDIX F

Procedure for Determining Dynamometer Frictional Power Losses

PROCEDURE FOR DETERMINING DYNAMOMETER FRICTIONAL POWER LOSSES

This specified procedure is used to determine the residual frictional horsepower losses caused by drive roll bearings, the engagement of flywheel bearings, and rotating component windage. The actual horsepower (HP_d) at the vehicle tire/roll interface can be calculated from the dissipation of kinetic energy as the dynamometer rolls and flywheels coast down through a known speed range at a measured time interval. The HP_d includes both frictional losses HP_f and power absorbed by the water brake, HP_i, which is indicated by the dynamometer horsepower display.

Thus:

$$HP_d = HP_f + HP_i$$

This procedure assumes that the torque, speed, and electronic circuits have been calibrated as previously described. The following is the procedure to be used.

1. Ensure that the cold room is at a nominal temperature of + 25°C (77°F);

2. Turn on dyno glycol pump;

3. Turn on - road load power control
   - coastdown timer

   and allow 30 minutes for electrical warmup and stabilization.

4. Check dyno air pressure;

5. Apply dyno lift brakes

6. Install and align the slave vehicle (rear wheel drive Ford Pinto) on the dyno rolls;

7. Set drive tire pressure to 45 psi;

8. Install the vehicle lifting device. Connect the air supply and electrical power. Verify proper operation (fast-up, slow-down);

9. Install - front wheel shocks;
   - exhaust ducting;
   - radiator and tire cooling fans;
   - tie-down straps
   - roll guards;

10. Open hood of slave vehicle;

11. Set dynamometer controls:

    Inertia Weight Selected - 2500#
    Thumbwheel Setting - 6.0 HP
    Selector Switch - Thumbwheel
    Vehicle Factor Pot - 0.0
    Press Index Light
    Speed Power Switch - Front Roll

Since all tests were run at an inertia weight setting of 2500#, this is the only setting considered in the frictional horsepower determination.

12. Release dyno lift brakes;

13. Switch on - building exhaust fan;
    - engine and roll fans;

14. Start slave vehicle;

15. Check that required inertia wheels are turning;

16. Run slave vehicle for 30 minutes at 60 mph to warm up dynamometer;

17. Accelerate to 50 mph front roll speed and verify that the selected thumbwheel value is within ±0.2 HP of the HP display. Record this data;

18. Accelerate to 62 mph and reset the coast down timer counter. Maintain for 60 seconds;

19. Activate the vehicle lift and maintain vehicle speed until the tires have cleared the roll. Release the accelerator;

20. Watch the timer and verify that the counter starts and stops at 88 and 72 km p.h. (55 and 45 mph);

21. Record coastdown time;

22. Bring the vehicle speedometer reading to within ±5 mph of the front roll speed and release the lifting device to allow the vehicle to contact rolls again;

23. Repeat steps 17 to 22 two more times;

24. If the three coastdown times recorded are not within 0.5 seconds, repeat steps 17 to 22 three more times;

25. Calculate HP_d using the following relationships:

$$HP_d = \frac{(\text{Inertia Weight} - 155\text{ lb}) \times 0.060734}{\text{Average Coastdown Time (Sec.)}}\text{ HP}$$

26. Repeat steps 17 to 25 for a thumbwheel setting of 8.0 HP and 10.0 HP;

27. Rear roll frictional determination speed-power switch - rear roll. Repeat steps 18-24;

28. Calculate the frictional horse power using the following relationships along with those in step 25:

$$HP_d\text{ rear roll} = \frac{155 \times 0.060734}{\text{Average Coastdown Time (Sec.)}}\text{ HP}$$

$$HP_f = HP_d + HP_d\text{ rear roll} - HP_i$$

29. Average the HP_f calculated in step 28 for 6.0, 8.0, and 10.0 HP_i. This average frictional horsepower should then be used for all testing at 2500# inertia weight;

30. Record all data on attached sheet;

31. Stop slave vehicle;

32. Turn off building exhaust fan and engine and roll fans; and,

33. Remove:
    - vehicle lift device
    - shocks
    - exhaust duct
    - cooling fans
    - tie-down strap
    - roll guards.

DYNAMOMETER COASTDOWN DATA SHEET

Date __________

Time __________

Cell Temp. __________

% RH __________

Barometric Pr. __________

Time Warmup started __________

completed __________

Time Coastdowns started __________

completed __________

Inertia Weight Setting 2500#

Coastdown Times

RL HP Setting (HP)	6.0	8.0	10.0	Rear Roll
Coastdown #1				
#2				
#3				
#4				
#5				
#6				
Average Time (sec.)				
HP_d				
HP_f				

Average HP_f @ 2500# __________

Comments: __________

Calculations:

$$HP_d = \frac{(\text{Inertia Wt} - 155\text{ lb}) \times .060734}{\text{Average Time}}$$

$$HP_d\text{ rear roll} = \frac{155 \times 0.060734}{\text{Average Time (sec)}}$$

$$HP_f = HP_d + HP_d\text{ rear roll} - HP_i$$

HP_d = __________ HP_f __________

APPENDIX G

Procedure for Plotting Torque Versus Speed and HP Versus Speed Curves

PROCEDURE FOR PLOTTING TORQUE; HORSEPOWER VS SPEED CURVES

This appendix describes the procedure for plotting the torque and horsepower versus speed curves through the electrical road load power control unit. By comparing these curves with the theoretical plots, one can tell immediately if there is a problem with calibration of the RLPC unit. The theoretical plots (see Figure A6-1) are based on an indicated power setting of 11.0 HP at 80 km/hr (50 mph) and are a function of the $T \propto V^2$ and $HP \propto V^3$ relationships. Typical test procedure is as follows:

1. Allow 30 minutes for electronic instrumentionation to stabilize.

2. Warmup dynamometer for 20 minutes.

3. Panel Setup:

Thumbwheel	11.0 HP
All switches	Run
Power Speed	Front
Mode	Thumbwheel
Vehicle Factor	0.0

4. Insert 11" x 14" sheet of graph paper containing theoretical curves in x-y plotter, zero the plotter and set the following spans:

   a) Torque - Speed Plot
      Torque - Y Axis; 2 volts = 54 lb_f - ft
      Speed - X Axis; 5 volts = 50 mph

   b) Horsepower - Speed Plot
      Horsepower - Y Axis; 0.5 volts = 20 HP
      Speed - X Axis; 5 volts = 50 mph

5. Plug leads from RLPC unit into the input of the X-Y recorder according to the following format:

   a) Torque - Speed Plot

      Torque - Y + Input; Terminal 316
      Y - Input; RLPC "common"

      Speed - X + Input; Terminal 325
      X - Input; RLPC "common"

   b) Horsepower - Speed Plot

      Horsepower - Y + Input; Terminal 301
      Y - Input; RLPC "common"

      Speed - X + Input; Terminal 325
      X - Input; RLPC "common"

(Note: Be careful not to short out the RLPC unit when connecting these leads.)

6. Lower the pen on the X-Y plotter and drive up to 60 mph on the dynamometer very slowly, change pen colors at 60 mph and decelerate slowly to a stop. (This procedure will have to be followed twice; once for torque vs speed curve, and once for the horsepower speed curve).

A comparison of the actual curves and those suggested by theory reveals a great deal about the state of the electrical RLPC unit. Some "hunting" on the torque-speed plot during acceleration is normal up to speeds of about 20 mph. Any oscillation in the curve beyond this speed indicates that the dead band adjustment portion of the RLPC calibration needs to be reset. If the exponent to the curve does not match that suggested by the manufacturer, then Section E of the factory calibration procedure (Appendix 3) needs to be repeated. If the exponent is correct but the curves are offset from the correct plots (and the zeros and spans were set correctly at the beginning), then a dead weight calibration should be done on the load cell (Section G-1 of basic calib - Appendix 4)

APPENDIX H

Propane Fuel Consumption Correction Factor

PROPANE FUEL CONSUMPTION CORRECTION FACTOR

The fuel consumption as derived from vehicle emissions as calculated from a normal gasoline emissions test is determined from a carbon balance formula. This formula is based on the composition of a standardized gasoline, indolene, normally used in emissions testing. Since the carbon-hydrogen ratio differs between indolene and propane, the conventional fuel consumption calculations will be incorrect for propane. To correct the carbon balance calculations for propane fuel consumption a correction factor is used.

	Carbon to Hydrogen Ratio	General Formula	Grams Carbon per Litre
Indolene	1.85	CH1.85	639.6
Propane Test Fuel	2.6667	CH2.6667	413.4

Grams Carbon/Litre Ratio $\frac{413.4}{639.6} = 0.6463$

Actual Fuel Consumption Propane $= \frac{\text{Calculated Fuel Consumption}}{0.6463}$

APPENDIX I

Dynamometer Horsepower Calculations For Different Test Temperatures

TRANSPORT CANADA/CHRYSLER CANADA

COLD WEATHER TEST PROGRAM

DYNO HORSE POWER CALCULATIONS

AIR RESISTANCE:

AERODYNAMIC FORCE REQUIRED (AFR) $= 1/2 \rho C_D A \; V^2/g_c$

ρ = Air Density lbm/ft^3

C_DA = Drag coefficient x frontal area ft^2

V = Vehicle speed $ft/_S$

g_c = $32.17 \; \dfrac{lbm \cdot ft}{lbf \cdot S^2}$

$\rho = \dfrac{P}{RT}$

P = Pressure absolute lb/ft^2

R = gas constant $53.3 \; \dfrac{lbm \cdot ft}{lb_f \, . \, ^oR}$

T = Temperature (^oR) $^oR = {}^oF + 459.67$

For 1979 OMNI/HORIZON - 4 Door

$V = 50$ mph $= 73.3 \; ft/_S$

$AFR = \dfrac{31460.4}{T} \; lb_f$

Table I

T ($^oF/^oC$)	AFR (lb_F)	H.P. @ 50 mph	Δ H.P. = ($HP_T - HP_{25}$)
$77^oF/25^oC$	58.62	7.82	0
$72^oF/ 0^oC$	63.99	8.53	0.7
$-4^oF/-20^oC$	69.04	9.21	1.4
$-31^oF/-35^oC$	73.39	9.79	2.0

Where $$H.P. = \frac{AFR\ (lb_F) \ \times \ V\ (ft/_S)}{550 \left(\dfrac{ft - lb_f}{S} \right)}$$

ROLLING RESISTANCE:

TIRES - 155 - 80 R 13

(Within approximately 10% of Actual)

at 60°F Rolling Resistance (RR) = 13 lb/thousand on road

below 30°F 4.3% increase per 10°F

Vehicle Inertia Weight (IW) = 2500 lb

Table II

T (°F/°C)	RR (lb_f)	H.P. @ 50 mph	ΔH.P. = ($HP_T - HP_{25}$)
77°F/25°C	32.50	4.33	0
32°F/ 0°C	32.50	4.33	0
-4°F/-20°C	37.39	4.99	0.7
-31°F/-35°C	41.30	5.51	1.2

Where $RR = \frac{13}{1000} \times IW, \quad (T > 30^\circ F)$

$$RR = \frac{13}{1000} \times IW + \frac{13}{1000} \times IW \times 0.043 \times \frac{(30^\circ F - T\ (^\circ F))}{10}, \quad (T < 30^\circ F)$$

$$HP = \frac{RR\ (lb_f) \times V\ (ft/s)}{550 \left(\frac{ft\ lb_f}{s}\right)}$$

Phase I Testing: Coast down times

Table III

T (°F/°C)	Δt (sec.)
77°F/25°C	11.81
32°F/ 0°C	11.38
- 4°F/-20°C	11.54
-31°F/-35°C	-

- 7.9 H.P. Dyno (Indicated + frictional)
- 45 psi cold tire pressure
- Average coast down times.

CONCLUSION:

- Phase I coast downs shown in table III indicate coast down times between test temperatures did not vary more than 3.5% with a fixed Dyno H.P. of 7.9 H.P. Therefore it appears rolling resistance does not increase at colder temperatures on the dynomometer with tire pressures of 45 psi and a fully warmed vehicle.

- To compensate for on road h.p. increase with colder temperatures due to air and rolling resistance the following dyno H.P. can be used for Phase II testing

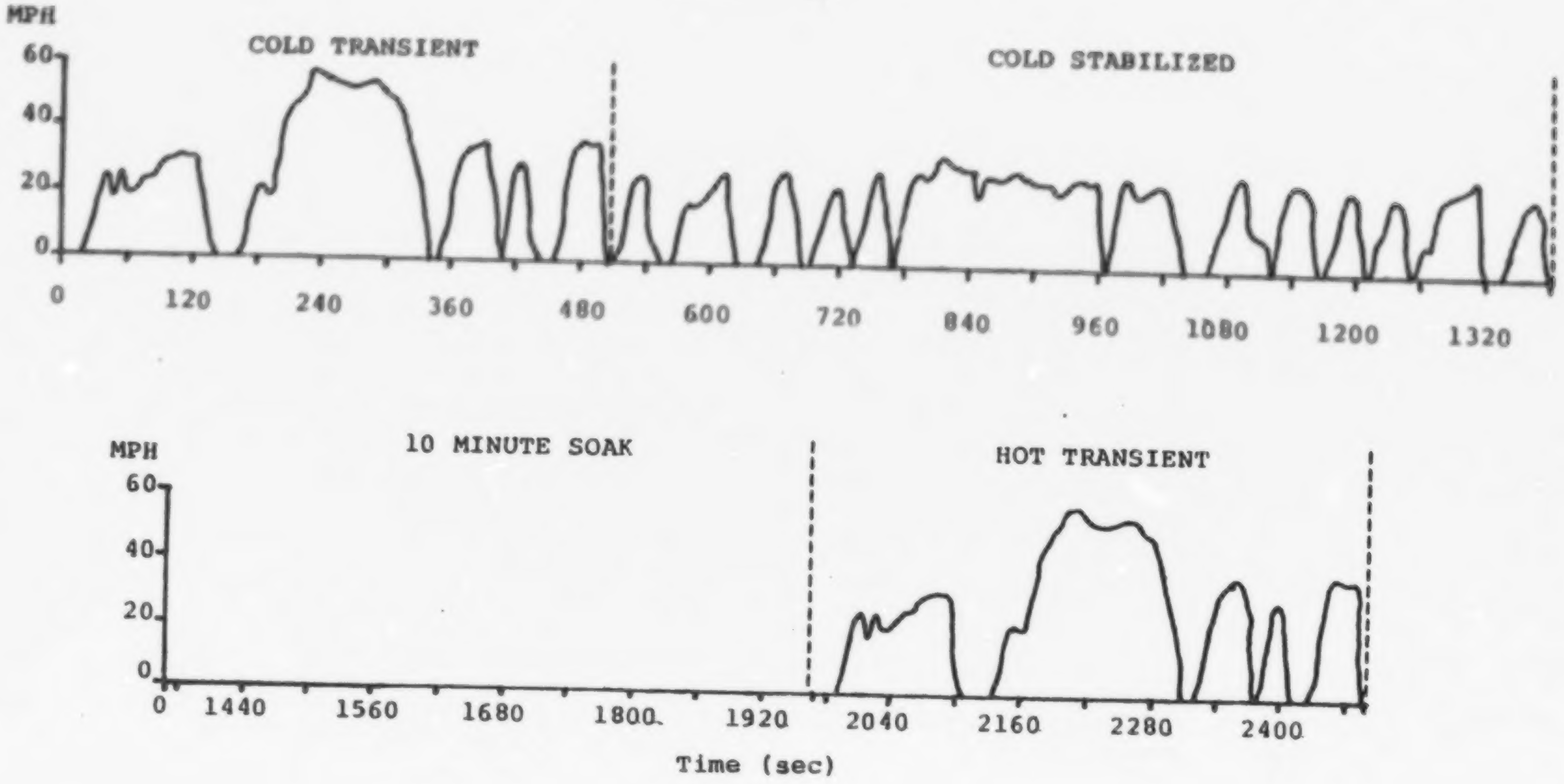
T (°C)	H.P. Base	$H.P._{AFR}$	$H.P._{RR}$	DYNO H.P.
25	7.9	-	-	7.9
0	7.9	0.7	-	8.6
-20	7.9	1.4	0.7	10.0
-35	7.9	2.0	1.2	11.1

APPENDIX J

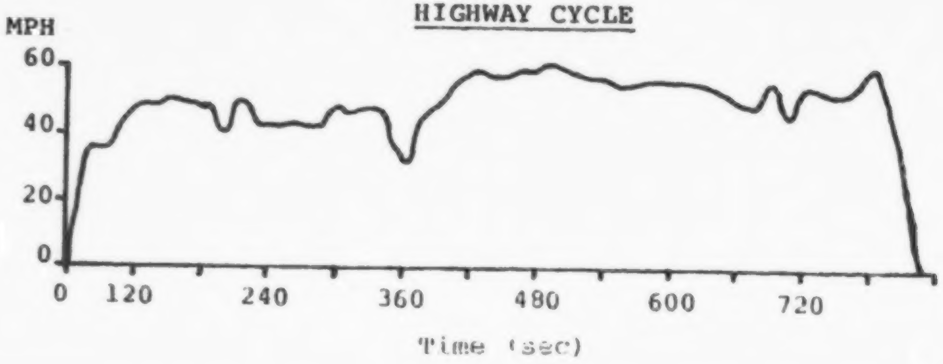
Transport Canada
Driving Cycles

Transport Canada Driving Cycles

CITY CYCLE



HIGHWAY CYCLE



APPENDIX K

Cold Weather Test Program Formal Lab Procedure And Test Data Summary

COLD WEATHER PROGRAM

DYNO TEST SUMMARY

GENERAL

Test No. ____________________

Date ____________________

Time (Start) ____________________

Vehicle No. ____________________

Driver ____________________

Instr. Op. ____________________

SOAK

Date/Time (Start) ____________________

Date/Time (End) ____________________

Soak Time ____________________

AV. Soak Temp ____________________

TEST PARAMETERS

Inertia Wt (lb) ____________________

H.P. - indicated ____________________

- determined ____________________

BATTERY S.G. ______ ______ ______

Min. 1250 ______ ______ ______

ODOMETER

CITY (DIST) ____________________

HWY (DIST) ____________________

TEST DIST (km) ____________________

INITIAL FUEL PRESSURE

Propane Vehicle ____________________

AMBIENT CONDITIONS COLD RM (AVERAGE)

Temp (°C) ____________________

Bar. Press. (mm Hg) ____________________

Rel. Humidity (%) ____________________

H (grains H_2O/lb air) ____________________

DILUTION AIR (AVERAGE)

Temp (°C) ____________________

Rel. Humidity (%) ____________________

VEHICLE TEST CONDITIONS COLD START

Time First Fire (sec) ____________________

Crank Time to Start (sec) ____________________

Cranking RPM ____________________

No. Die Outs ____________________

Fast Idle RPM ____________________

Choke Full Off Time (sec) ____________________

VEHICLE WARMED UP

Ave. Fuel Temp (°C) ____________________

Hot Curb Idle ____________ ________

Basic Timing (Hot) ____________________

Manifold Vacuum (in Hg) ____________________

N/V (RPM/50 mph) ____________________

Carb in Temp (°C) ____________________

Quick Coast Downs (sec)

__________ __________ __________

__________ __________

FUEL CONSUMPTION RESULTS

City ____________________ Highway ____________________

TEST DATA SUMMARY
EMISSIONS & FUEL CONSUMPTION

TEST NO.________
DATE________
TIME________
VEHICLE________

COLD RM CONDITIONS

AVE. TEMP____________°C
BAR PRESS____________mm Hg
REL HUMIDITY____________%
H (grains H_2O/lb dry air________

DILUTION AIR CONDITIONS

AVE TEMP____________°C
REL HUMIDITY____________%

BAG 1

FUEL USED____________gms
DYNO REVS____________
CVS VOL____________SCF

	ppm	ppm	ppm	%
	HC	NOx	CO	CO_2
RANGE			L/H	
SAMPLE				
BACKGROUND				

BAG 2

FUEL USED____________gms (tot)
DYNO REVS____________(tot)
CVS VOL____________SCF (Bag)

	HC	NOx	CO	CO_2
RANGE			L/H	
SAMPLE				
BACKGROUND				

BAG 3

FUEL USED____________gms (Tot)
DYNO REVS____________(Tot)
CVS VOL____________SCF (Bag)

	HC	NOx	CO	CO_2
RANGE			L/H	
SAMPLE				
BACKGROUND				

HIGHWAY (BAG 4)

FUEL USED____ - ____ = ____gms (bag)
DYNO REVS____ - ____ = ____(bag)
CVS VOL____________SCF (bag)

	HC	NOx	CO	CO_2
RANGE			L/H	
SAMPLE				
BACKGROUND				

Revised to Mar. 22/82

LABORATORY TEST PROCEDURE

N.B. The dynamometer must have been operated within the past:

- two hours at ambient temperature of $20^{\circ}C$ to $30^{\circ}C$;
- one hour at ambient temperature $< 20^{\circ}C$;

otherwise a dyno warm-up would be required.

INITIAL PREPARATION

- Emissions Sampler & Analysers on & warmed up (See Operation of CVS) (______min.) ☐
- Auto Purge bags (See Operation of CVS) ☐
- Tire pressure 45 psi ☐
- Measure battery S.G. (change battery if necessary) ☐
- Dyno air pressure - 70 psi ☐
- Load Test Vehicle program in Datalogger ☐

TEST PREPARATION

Vehicle

- Apply dyno lift brakes (roll brakes light - ON) ☐
- Put test vehicle on dyno. DO NOT START ENGINE. ☐
- Release dyno lift brakes (roll brakes-light off) ☐
- Align test vehicle by MANUALLY rotating rolls several turns until vehicle centred ☐

- Install · Chocks ☐
  - · Safety straps ☐
  - · Roll guards ☐
  - · Fans ☐
  - · Coupling to CVS pipe ☐
- Vehicle Electrical Accessories - Off

NOTE: at 0°C set heater controls to:

Fan on low, heater on full and selector in heater position.

at -20°C set heater controls to:

Fan on high, heat full on, and selector in heater position. Fan on medium for highway.

- Record Odometer reading ______________________ km

Fuel System Connection and Purging

(For Vehicles 1 & 3 Only)

- Turn off electric fuel pump ☐
- Open electric fuel pump bypass valve (solenoid valve) ☐
- Close carburetor supply valve ☐
- Close vehicle mechanical fuel pump supply valve ☐
- Open purge valve in return circuit ☐
- Connect feed and return lines at test vehicle ☐
- Close electric fuel pump bypass valve (solenoid valve) ☐

- Turn on electric fuel pump and purge until all air evacuated ☐
- Open carburetor supply valve SLOWLY ☐
- Close purge valve in return circuit ☐
- Close return line valve at fuel cannister ☐
- Open slave cannister lock off valve ☐
- Close in vehicle cannister lock off valve ☐

Transducer Hook-ups to Test Vehicle

CAUTION: KEEP ALL CABLES AWAY FROM FAN

- Connect vehicle battery (Master Power Switch) ☐
- Install magnetic timing probe ☐
- Install inductance clip on cyl #1 high tension lead ☐
- Install vacuum transducer & fuel pressure connects ☐
- Connect electrical signal leads ☐
- Connect choke position transducer leads ☐
  CHECK POSITION ON WATANABE
- Connect thermocouple leads ☐
- Place driver's remote control box in test vehicle ☐
- Close test vehicle hood ☐

Road Load Power Control

- Dyno glycol circulation pump ON ☐
- Apply dyno lift brakes ☐
- Roll brakes light ON ☐
- 2500# inertia weight selected? ☐
- release dyno lift brakes (Roll Brakes - light OFF) ☐

- Dyno frictional power for 2500 lb ☐

  ____________ H.P.

- Date of mechanical cal chart used ____________
- Indicated power 7.9 HP - frictional HP for +25°C

  8.6 HP - frictional HP for 0°C

  10.0 HP - frictional HP for -20°C

  11.1 HP - frictional HP for -35°C
- Thumbwheel set at ____________ HP

  ____________ HP
- Selector switch in Thumbwheel position ☐
- Vehicle factor potentiometer set at 0.00 ☐
- Press index light - light flashing ☐
- Speed/Power switch - REAR ROLL ☐
- Check driver's aid - paper ☐

  - ink ☐
  - pen ☐
  - electrical zero ☐
- Position driver's aid chart at 0 sec ☐

Instrumentation

- Weight scale levelled ☐
- Check Watanabe paper ☐
- Check Watanabe traces (all channels operating) ☐
- Check Datalogger (all channels operating) ☐
- Check printer paper ☐
- Install recording disc (floppy) ☐
- Record cell barometric pressure ☐

TEST CYCLES

N.B. 1) Follow manufacturer's starting procedures.

Cold Start at 25°C and 0°C: Vehicles 1 & 3

a) Depress accelerator pedal all the way to the floor and release.

b) Turn key to start engine.

c) Let engine idle for 5 seconds, then lightly depress and release accelerator pedal.

Cold Start at -20°C: Vehicles 1 & 3

Depress the accelerator pedal all the way to the floor, release and depress to 1/3 throttle open position, and hold accelerator pedal in this position while starting engine.

Cold Start - All Test Temps.: Vehicle 9

a) Depress accelerator pedal to 1/3 open positions & hold while starting engine.
b) Turn key to start engine.
c) Slowly return accelerator pedal to idle.

2) Be familiar with Annex F - Stalling and Restarting

Hot Start (After 10 min. Soak At All Temps.): All Vehicles

Depress accelerator pedal to 1/3 open throttle and hold while starting engine.

City Cycle

- Start Large Fans & Roll Fans ☐
- Turn on CVS blower (See Operation of CVS) ☐
- Zero weigh scale ☐
- Zero roll rev counter ☐
- Start Datalogger (printer and recorder) ☐
- For Car #9, 2 minute warmup, CVS on when ignition on, heater fan off until driver's aid is started ☐

BAG 1

- Start Watanabe at 600 mm/min ☐
- Switch CVS control to Test 1 & Start Test vehicle ☐
- Reduce Watanabe chart speed to 75 mm/min after test vehicle starts ☐
- Indicate change of Watanabe chart speed on chart paper ☐

Vehicle #9 -20°C Test Temp.

- Initiate datalogger reading when engine starts ☐
- Idle engine with heater fan off for 2 minutes before starting driver's aid ☐
- SIMULTANEOUSLY (when engine starts)
    - start driver's aid ☐
    - initiate Datalogger reading ☐
    - indicate time 0 on data printout ☐
    - turn heater fan on (Vehicle #9 -20°C) ☐
    - at the end of every hill (vehicle just stopped) initiate Datalogger reading - Driver ☐
    - switch fuel pump & solenoid valves to normal ☐

At 505 Sec.

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - initiate Datalogger reading ☐
    - switch CVS control from Test 1 to Test 2 ☐

- MANUALLY record: - Fuel used ____________ gm
  - Dyno roll revs ____________
  - CVS volume ____________ std cu ft
- indicate 505 sec. on data printout (Data logger output & Watanabe chart) ☐

BAG 2

(During Sampling of Bag 2, analyse Bag 1: See "Bag Analysis")

At 1369 Sec.

- SIMULTANEOUSLY
  - turn off vehicle ignition ☐
  - sound test vehicle horn ☐
  - initiate Datalogger reading ☐
  - MANUALLY record: - Fuel used ____________ gm
    - Dyno roll revs ____________
  - 5 seconds after engine stops (includes any dieseling) switch CVS switch control from Test 2 to Stops Test (T = 869 on CVS) ☐
  - Indicate 1369 sec. on data printout ☐
    - CVS volume ____________ std cu ft

HOT SOAK

- Stop cooling fans ☐
- Stop CVS blower ☐
- Position driver's aid at 0 sec. ☐

- Analyse Bag 2 (See "Bag Analysis") ☐
- Just before 10 min.
    - start CVS blower ☐
    - start cooling fans ☐
- At 10 min. start BAG 3 ☐

BAG 3

DO NOT ZERO SCALE OR ROLL REV COUNTER

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - start test vehicle engine ☐
    - switch CVS control from Stop Test to Test 3 ☐
- SIMULTANEOUSLY (When Engine Starts)
    - start driver's aid ☐
    - initiate Datalogger reading ☐
    - indicate start of BAG 3 on data printout ☐

At 505 Sec.

- SIMULTANEOUSLY
    - sound test vehicle horn ☐
    - initiate Datalogger reading ☐
    - switch CVS control from Test 3 to Stop Test ☐

- MANUALLY record: - Fuel used ______________________ gm
  - Dyno roll revs __________________ .
  - CVS volume _____________ std cu ft
- Leave test vehicle running ☐
- Record cell barometric pressure ________________ in. Hg.
- Record Odometer reading ____________________________ km
- Leave test vehicle running & shift to neutral ☐
- When idle stable,
  - MANUALLY record: - hot curb idle __________________ rpm
    - basic timing __________________
  - Initiate Datalogger reading and note:
    - · manifold vacuum ___________________________ in. Hg.
    - · carb in temp. _______________________________ °C
    - · fuel temperature _______________________________ °C
    - · cell temperature _______________________________ °C

Preconditioning

- Stop data logger (Printer & Recorder) ☐
- Open in vehicle cannister lock off valve ☐
- Close slave cannister lock off valve ☐
- Run test vehicle at 50 mph for 15 minutes (REDUCE SPEED IF ENGINE OVERHEATING) ☐
- During preconditioning run analyse Bag 3 (see "Bag Analysis") and purge bags ☐

- Perform 5 quick coastdowns (run vehicle at 60 mph for 60 sec. prior to each coastdown) ________ sec

________ sec

________ sec

________ sec

________ sec

Highway Cycle

N.B. Highway Preconditioning to be performed if test vehicle has been stopped for longer than 15 minutes.

DO NOT ZERO SCALE OR ROLL REV COUNTER

N.B. Ensure Consistent time between last coastdown and start of highway (1 minute).

- Open slave cannister lock off valve ☐
- Close in vehicle cannister lock off valve ☐
- Close test vehicle hood ☐
- Check fuel container for adequate fuel ☐
- Check driver's aid - paper ☐
  - ink ☐
  - pen ☐
  - zero ☐
- Check Watanabe paper ☐
- Check printer paper ☐
- Check recording disc ☐
- Start Data logger (printer & recorder) ☐
- Record Odometer reading ________________ km ☐
- Start Highway Test Cycle ☐

- SIMULTANEOUSLY at chart instruction "Start of Sample Period"
  - sound test vehicle horn ☐
  - initiate Datalogger reading ☐
  - manually record: - Fuel used ______________________gm
    - Dyno Roll Revs ______________________
  - CVS control to Test 1 ☐
  - indicate start of Highway Test Cycle on data printout ☐

At End of HWFET Sample Period (765 sec.)

- SIMULTANEOUSLY
  - sound test vehicle horn ☐
  - initiate Datalogger reading ☐
  - CVS control from Test 1 to Stop Test ☐
  - MANUALLY record: - Fuel used __________ - ____ = ______ gm
    - Dyno Roll Revs ______ - ____ = ______
    - CVS Volume ______________ std cu ft
- Record Odometer reading ______________________________ km
- Stop Datalogger (printer & recorder) ☐
- Open in vehicle cannister lock off valve ☐
- Close slave cannister lock off valve ☐

NOTE: If fuel cannister requires fuel fill at this time, this can be accompished by doing the following:

a) turn off electric fuel pump;

b) open bypass (solenoid valve); and,

c) open vehicle mechanical fuel pump supply valve.

Watch closely that an overflow condition does not occur at the fuel cannister.

- Stop test vehicle engine ☐
- Stop cooling fans ☐
- Stop CVS blower ☐
- Open test vehicle hood ☐
- Deinstrument test vehicle ☐
- Disconnect test vehicle battery (using master disconnect switch) ☐
- Analyse Highway Emissions - Bag 1 (do this as soon as possible after completion of test) ☐
- Close hood of test vehicle ☐
- Apply dyno lift brakes (Roll brakes light ON) ☐
- Remove:
  - chocks ☐
  - safety straps ☐
  - roll guards ☐
  - fans ☐
  - CVS coupling ☐
- Remove test vehicle from dyno (DO NOT START TEST VEHICLE ENGINE) ☐
- Record cell barometric pressure ____________________ in. Hg.

City Fuel Consumption Calculation

Fuel Consumed (gm):

= [0.43(BAG 1) + (BAG 2) + 0.57(BAG 3)]

= 0.43 (   ) + (   ) + 0.57(   )

= ________________ gm

Roll Revs:

= 0.43(BAG 1) + (BAG 2) + 0.57(BAG 3)

= 0.43(   ) + (   ) + 0.57(   )

= ________________ revs.

Fuel Consumption (1/100 km):

$$= \frac{\text{Fuel Consumed (gm)} \times 144.686}{\text{Roll Revs} \times \text{Fuel Specific Gravity}}$$

$$= \frac{(\qquad) \times 144.686}{(\qquad) \times 0.7088}$$

= ________________ 1/100 km

- Report result on first page ☐

Highway Fuel Consumption Calculation (See Annex D)

Highway Fuel Consumption (1/100 km):

$$= \frac{\text{Fuel Consumed (gm)} \times 144.686}{\text{Roll Revs} \times \text{Fuel Specific Gravity}}$$

$$= \frac{(\qquad) \times 144.686}{(\qquad) \times 0.7088}$$

= ________________ 1/100 km

- Report result on first page ☐

Comments: (record any test abnormalities or pertinent comments)

CITY:

PRECONDITIONING:

HIGHWAY:

TEST #________________

TIMES AT EACH SECTION

DESCRIPTION	DAY	HR	MIN	SEC
Start				
505 Sec Mark				
1369 Sec Mark				
End of Soak				
End of Hot 505 Sec Mark				
Start of Highway				
End of Highway				

TEST TIMES

DESCRIPTION	TOTAL TIME min/sec
City Cycle	
10 Min Soak Period	
Preconditioning Run	
Highway Cycle	

TEST #________________________

COEFFICIENT OF VARIATION REPORT

1. City Cycle

n	TEST#	F.C. 1/100 km	Mean	ST. DEV.	C.V.
2					
3					
4					

2. Highway Cycle

n	TEST#	F.C. 1/100 km	Mean	ST. DEV.	C.V.
2					
3					
4					

APPENDIX L

Test Quality Control Data

TRANSPORT CANADA/CHRYSLER CANADA COLD WEATHER TEST PROGRAM

PHASE II TEST TOLERANCES

ALL VEHICLE TOLERANCES TO BE CHECKED AT THE END OF BAG 3 WITH THE VEHICLE IN NEUTRAL.

ITEM	VEHICLE #1 O.C.T.	VEHICLE #3 AIS	VEHICLE #9 PROPANE
HOT CURB IDLE	850 - 1100	900 - 1100 Base 800 - 900 with A.I.S.	850 - 1000
BASIC TIMING	15° - 19°	13° - 17°	30° - 34°
CARB. IN TEMP.	24°C → 45°C @ + 25°C TEST TEMP. 10°C → 27°C @ 0°C &-20°C TEST TEMP.		NO TOLERANCE. RECORD TEMP. ONLY.
MANIFOLD VACUUM	17" - 20" Hg		
AVG. CELL TEMP.	± 5°C @ + 25°C TEST TEMP. ± 2°C @ 0°C & - 20°C TEST TEMP.		
AVG. FUEL TEMP.	NO TOLERANCE - RECORD TEMP. ONLY		

CHRYSLER CANADA LTD.
PRODUCT ENGINEERING
82-03-29. (Revised)

TEST #________

TEST QUALITY CONTROL SHEET

N.B. The following criteria should be considered when assessing the validity and subsequent acceptance or rejection of a test run. These criteria should be used as a guide with judgment exercised in the final decision.

Item	Test Value	Suggested Tolerance	In Tol.	Out of Tol.
Driver's aid trace*		See para 8.6.2 of Test Method		
At end of BAG 3 Hot Curb Idle Basic Timing Manifold Vac. Carb in Temp				
Av. Cell Temp				
Av. Fuel Temp		---		
Bag 1 Roll Revs		8150 - 8575		
Bag 2 Roll Revs		8750 - 9290		
Bag 3 Roll Revs		8230 - 8570		
Highway Roll Revs		23220 - 24650		
Av. Quick Coastdown		---		
Total Test Time Soak Time		52 - 56 min 10 min ±10 sec		
ODO Distance		32 - 36 km		

* Note times at which out of tolerance ______________________________

____

Run: Valid ☐ , Void ☐

APPENDIX M

Fuel Consumption & Exhaust Emissions Calculation Computer Program

```
      PROGRAM CHRYEM
C
C     81-140 CHRYSLER PROGRAM PHASE 2 FEB:82
C
C
C
C     PROGRAM TO READ IN, CALCULATE AND DISPLAY EMISSIONS AND
C     FUEL CONSUMPTION/ECONOMY DATA AND RESULTS
C
C
C
C
C
C
      INTEGER CAR,CRTEMP,CRBP,CRRH,H,DATEMP,DARH,RANGE,I
     1,TSTNO,DATE,TIME,FNAME

      REAL FSG,KH,NOXE,NOXD,NOXCON,NOXMAS,NOXBAG,NOXMI
      1   ,NOXWM,NOXWMI
C
      DIMENSION TSTNO(4),DATE(5),TIME(3),GRAMS(4),REVS(4),VMIX(4),
      &RANGE(4),HCE(4),HCD(4),NOXE(4),COEM(4),CODM(4),CO2E(4),FUEL(4),
      &DREVS(4),COE(4),COD(4),DF(4),HCCON(4),HCMAS(4),NOXD(4),
      &CO2D(4),NOXCON(4),COCON(4),CO2CON(4),NOXMAS(4),COMAS(4),
     1CO2MAS(4),HCBAG(4),NOXBAG(4),COBAG(4),CO2BAG(4),FCBAG(4),
     1FCBGV(4),HCMI(4),NOXMI(4),COMI(4),CO2MI(4),FCMI(4),
     1FCUS(4),FCBGRV(4),FCGVMI(4),FCGVUS(4),FNAME(8)

      IR1=7
      IR2=7
       WRITE(IR2,6)
6      FORMAT(/1X,'ENTER LIST DEVICE '$)
       READ(IR1,7) IR3
7      FORMAT(I2)
       IF(IR3.NE.0)GO TO 10
C
C      PROMPT FOR INPUT FILE NAME
C
       WRITE(IR2,8)
8      FORMAT(/1X,'ENTER FILE NAME '$)
C
       READ(IR1,9)FNAME
9      FORMAT(8A2)
C
C      OPEN UP FILE TO RECIEVE DATA
C
       IR3=1
       OPEN(UNIT=1,TYPE='NEW',NAME=FNAME)
C
C      DATE ENTRY-GENERAL
C
C
10     WRITE(IR2,32)
32   . FORMAT(/T6'COMMON DATA ENTRY'/T6'TEST NO='$)
       READ(IR1,34) TSTNO
34     FORMAT(4A2)
       WRITE(IR2,36)
36     FORMAT(/T6'ENTER DATE (DD-MMM-YY) '$)
       READ(IR1,38) DATE
38     FORMAT(5A2)
       WRITE(IR2,39)
39     FORMAT(/T6'ENTER TIME (HH:MM) '$)
```

```
      READ(IR1,38) TIME
      WRITE(IR2,40)
40    FORMAT(/T6'VEHICLE NO='$)
      READ(IR1,42) CAR
42    FORMAT(I1)
C
C     ENTER GENERAL TEST CONDITIONS
C
      WRITE(IR2,44)
44    FORMAT(/T6'ENTER COLD ROOM AVE TEMP(C),BP(MM/HG),%RH')
      READ(IR1,46) CRTEMP,CRBP,CRRH
46    FORMAT(3I5)
      WRITE(IR2,48)
48    FORMAT(/T6'ENTER COLD RM. "H" FROM PSYCHOMETRIC CHART-UNITS
     $(GRAINS H2O/LB DRY AIR)')
      READ(IR1,50) H
50    FORMAT(I3)
      WRITE(IR2,52)
52    FORMAT(/T6'ENTER DILUTION AIR CONDITIONS-AVE. TEMP.(C),%RH')
      READ(IR1,54) DATEMP,DARH
54    FORMAT(2I5)
C
C
C
C     DATA ENTRY TEST DATA BAGS 1-3, HIGHWAY
C
C
      DO 100 I=1,4
      WRITE(IR2,62) I
62    FORMAT(/T6'ENTER TEST DATA FOR BAG',I1)
      IF(CAR.EQ.9) GO TO 68
      WRITE(IR2,64)
64    FORMAT(/T6'FUEL USED(GMS)='$)
      READ(IR1,66) GRAMS(I)
66    FORMAT(F6.1)
68    CONTINUE
      WRITE(IR2,70)
70    FORMAT(/T6'ENTER DYNO REVS AND CVS VOLUME')
      READ(IR1,72) REVS(I),VMIX(I)
72    FORMAT(F7.1,F7.1)
      WRITE(IR2,74)
74    FORMAT(/T6'ENTER 0 FOR LCO $ 1 FOR HCO')
      READ(IR1,76) RANGE(I)
76    FORMAT(I1)
      WRITE(IR2,78)
78    FORMAT(/T6'ENTER SAMPLE VALUES FOR HC,NOX, CO,CO2')
      READ(IR1,80) HCE(I),NOXE(I),COEM(I),CO2E(I)
      WRITE(IR2,82)
82    FORMAT(/T6'ENTER BACKROUND VALUES FOR HC,NOX,CO,CO2')
      READ(IR1,80) HCD(I),NOXD(I),CODM(I),CO2D(I)
80    FORMAT(3F8.2,F7.4)
100   CONTINUE
C
C
C     CONSTANT DATA FUEL SP GRAVITY
C
C
C
      FSG=0.7088
      DHCGAS=16.33
      DHCPRP=16.33
      DNOX=54.16
      DCO=32.97
      DCO2=51.85
      DHC=DHCGAS
      IF(CAR.EQ.9) DHC=DHCPRP
C
C
C
C     SPLIT FUEL USED AND DYNO REVS INTO BAGS
C
C
C
      IF(CAR.EQ.9)GO TO 110
      FUEL(1)=GRAMS(1)
      FUEL(2)=GRAMS(2)-GRAMS(1)
      FUEL(3)=GRAMS(3)-GRAMS(2)
      FUEL(4)=GRAMS(4)
 110  CONTINUE
      DREVS(1)=REVS(1)
      DREVS(2)=REVS(2)-REVS(1)
      DREVS(3)=REVS(3)-REVS(2)
      DREVS(4)=REVS(4)
C
C
C
      KH=1./(1.-0.0047*(FLOAT(H)-75.))
C
C
      DO 200 I=1,4
      IF(RANGE(I).EQ.0) GO TO 120
      COE(I)=(1.-0.01925*CO2E(I)-0.000323*FLOAT(DARH))*COEM(I)
      COD(I)=(1.-0.000323*FLOAT(DARH))*CODM(I)
      GO TO 130
 120  CONTINUE
      COE(I)=COEM(I)
      COD(I)=CODM(I)
 130  CONTINUE
     DF(1)=13.4/(CO2E(I)+0.0001*(HCE(I)+COE(I)))
C
C
C     CALCULATE BAG CONCENTRATIONS
C
C
      X=(1.-1./DF(I))
      HCCON(I)=HCE(I)-HCD(I)*X
      NOXCON(I)=NOXE(I)-NOXD(I)*X
      COCON(I)=COE(I)-COD(I)*X
      CO2CON(I)=CO2E(I)-CO2D(I)*X
C
C     CALCULATE EMISSIONS (GRAMS/TEST PHASE)
C
      HCMAS(I)=(VMIX(I)*DHC*HCCON(I))/1000000.
      NOXMAS(I)=(VMIX(I)*DNOX*NOXCON(I)*KH)/1000000.
      COMAS(I)=(VMIX(I)*DCO*COCON(I))/1000000.
      CO2MAS(I)=(VMIX(I)*DCO2*CO2CON(I))/100.
C
C     CALCULATE EMISSIONS (GRAMS/KM.) PER TEST PHASE
C
      HCBAG(I)=(HCMAS(I)*1446.86)/DREVS(I)
      NOXBAG(I)=(NOXMAS(I)*1446.86)/DREVS(I)
      COBAG(I)=(COMAS(I)*1446.86)/DREVS(I)
      CO2BAG(I)=(CO2MAS(I)*1446.86)/DREVS(I)
C
```

```
      READ(IR1,38) TIME
      WRITE(IR2,40)
 40   FORMAT(/T6'VEHICLE NO='$)
      READ(IR1,42) CAR
 42   FORMAT(I1)
C
C     ENTER GENERAL TEST CONDITIONS
C
      WRITE(IR2,44)
 44   FORMAT(/T6'ENTER COLD ROOM AVE TEMP(C).BP(MM/HG),%RH')
      READ(IR1,46) CRTEMP,CRBP,CRRH
 46   FORMAT(3I5)
      WRITE(IR2,48)
 48   FORMAT(/T6'ENTER COLD RM. "H" FROM PSYCHOMETRIC CHART-UNITS
     &(GRAINS H2O/LB DRY AIR)')
      READ(IR1,50) H
 50   FORMAT(I3)
      WRITE(IR2,52)
 52   FORMAT(/T6'ENTER DILUTION AIR CONDITIONS-AVE. TEMP.(C),%RH')
      READ(IR1,54) DATEMP,DARH
 54   FORMAT(2I5)
C
C
C
C     DATA ENTRY TEST DATA BAGS 1-3, HIGHWAY
C
C
      DO 100 I=1,4
      WRITE(IR2,62) I
 62   FORMAT(/T6'ENTER TEST DATA FOR BAG',I1)
      IF(CAR.EQ.9) GO TO 68
      WRITE(IR2,64)
 64   FORMAT(/T6'FUEL USED(GMS)='$)
      READ(IR1,66) GRAMS(I)
 66   FORMAT(F6.1)
 68   CONTINUE
      WRITE(IR2,70)
 70   FORMAT(/T6'ENTER DYNO REVS AND CVS VOLUME')
      READ(IR1,72) REVS(I),VMIX(I)
 72   FORMAT(F7.1,F7.1)
      WRITE(IR2,74)
 74   FORMAT(/T6'ENTER 0 FOR LCO & 1 FOR HCO')
      READ(IR1,76) RANGE(I)
 76   FORMAT(I1)
      WRITE(IR2,78)
 78   FORMAT(/T6'ENTER SAMPLE VALUES FOR HC,NOX, CO,CO2')
      READ(IR1,80) HCE(I).NOXE(I),COEM(I),CO2E(I)
      WRITE(IR2,82)
 82   FORMAT(/T6'ENTER BACKROUND VALUES FOR HC,NOX,CO,CO2')
      READ(IR1,80) HCD(I),NOXD(I),CODM(I),CO2D(I)
 80   FORMAT(3F8.2,F7.4)
 100  CONTINUE
C
C
C     CONSTANT DATA FUEL SP GRAVITY
C
C
C
      FSG=0.7088
      DHCGAS=16.33
      DHCPRP=16.33
      DNOX=54.16
      DCO=32.97
      DCO2=51.85
      DHC=DHCGAS
      IF(CAR.EQ.9) DHC=DHCPRP
C
C
C
C     SPLIT FUEL USED AND DYNO REVS INTO BAGS
C
C
C
      IF(CAR.EQ.9)GO TO 110
      FUEL(1)=GRAMS(1)
      FUEL(2)=GRAMS(2)-GRAMS(1)
      FUEL(3)=GRAMS(3)-GRAMS(2)
      FUEL(4)=GRAMS(4)
110   CONTINUE
      DREVS(1)=REVS(1)
      DREVS(2)=REVS(2)-REVS(1)
      DREVS(3)=REVS(3)-REVS(2)
      DREVS(4)=REVS(4)
C
C
C
      KH=1./(1.-0.0047*(FLOAT(H)-75.))
C
C
      DO 200 I=1,4
      IF(RANGE(I).EQ.0) GO TO 120
      COE(I)=(1.-0.01925*CO2E(I)-0.000323*FLOAT(DARH))*COEM(I)
      COD(I)=(1.-0.000323*FLOAT(DARH))*CODM(I)
      GO TO 130
120   CONTINUE
      COE(I)=COEM(I)
      COD(I)=CODM(I)
130   CONTINUE
     DF(1)=13.4/(CO2E(I)+0.0001*(HCE(I)+COE(I)))
C
C
C     CALCULATE BAG CONCENTRATIONS
C
C
      X=(1.-1./DF(I))
      HCCON(I)=HCE(I)-HCD(I)*X
      NOXCON(I)=NOXE(I)-NOXD(I)*X
      COCON(I)=COE(I)-COD(I)*X
      CO2CON(I)=CO2E(I)-CO2D(I)*X
C
C     CALCULATE EMISSIONS (GRAMS/TEST PHASE)
C
      HCMAS(I)=(VMIX(I)*DHC*HCCON(I))/1000000.
      NOXMAS(I)=(VMIX(I)*DNOX*NOXCON(I)*KH)/1000000.
      COMAS(I)=(VMIX(I)*DCO*COCON(I))/1000000.
      CO2MAS(I)=(VMIX(I)*DCO2*CO2CON(I))/100.
C
C     CALCULATE EMISSIONS (GRAMS/KM.) PER TEST PHASE
C
      HCBAG(I)=(HCMAS(I)*1446.86)/DREVS(I)
      NOXBAG(I)=(NOXMAS(I)*1446.86)/DREVS(I)
      COBAG(I)=(COMAS(I)*1446.86)/DREVS(I)
      CO2BAG(I)=(CO2MAS(I)*1446.86)/DREVS(I)
C
```

```
C       FUEL CONSUMPTION CARBON BALANCE PER TEST PHASE (L/100KM.)
C
        FACTOR=1.0
        IF(CAR.EQ.9) FACTOR=0.6463
        FCBAG(I)=((0.866*HCBAG(I))+(0.429*COBAG(I))+(0.273*CO2BAG(I)))/
        1  (10.29*0.62137*FACTOR)
        IF(CAR.EQ.9) GO TO 140
C
C       FUEL CONSUMPTION GRAVIMETRIC PER TEST PHASE  (L/100KM.)
C
        FCBGRV(I)=(FUEL(I)*144.686)/(DREVS(I)*FSG)
140     CONTINUE
200     CONTINUE
C
C       WEIGHTED MASS EMISSIONS CALCULATION (BAGS 1,2,3 GM./KM.)
C
        D1=(DREVS(1)+DREVS(2))/1446.86
        D2=(DREVS(2)+DREVS(3))/1446.86
        HCWM=(0.43*((HCMAS(1)+HCMAS(2))/D1))+(0.57*((HCMAS(2)+
        1  HCMAS(3))/D2))
        NOXWM=(0.43*((NOXMAS(1)+NOXMAS(2))/D1))+(0.57*((NOXMAS(2)+
        1  NOXMAS(3))/D2))
        COWM=(0.43*((COMAS(1)+COMAS(2))/D1))+(0.57*((COMAS(2)+
        1  COMAS(3))/D2))
        CO2WM=(0.43*((CO2MAS(1)+CO2MAS(2))/D1))+(0.57*((CO2MAS(2)+
        1  CO2MAS(3))/D2))
C
C       WEIGHTED FUEL CONSUMPTION CALCULATION (CARBON BALANCES)
C
        FACTOR=1.0
        IF(CAR.EQ.9) FACTOR=0.6463
C
        FCWTCB=((0.866*HCWM)+(0.429*COWM)+(0.273*CO2WM))/
        1  (10.29*0.62137*FACTOR)
C
C
        IF(CAR.EQ.9)GO TO 240
C
C
C
C       WEIGHTED FUEL CONSUMPTION GRAVIMETRIC (BAGS 1,2,3)
C
        FCWTGV=((0.43*((FUEL(1)+FUEL(2))/D1))+(0.57*((FUEL(2)+FUEL(3))
        1  /D2)))/(10*FSG)
C
240     CONTINUE
C
C
C       DATA PRINTOUT
C
C
        WRITE(IR3,310)TSTNO,DATE,CRTEMP,DATEMP,TIME,CRBP,DARH,CAR,
        1  CRRH,H
310     FORMAT(/T27'TEST DATA SUMMARY'//T6'TEST NO=',4A2,3X,
        1  'COLD ROOM CONDITIONS/DILUTION AIR CONDITIONS'/T6'DATE  =',
        1  5A2,2X,'AVE TEMP =',I3,'C        AVE TEMP= ',I3,'C',
        1  /T6'TIME  =',3A2
        1   ,4X,'  BAR PRESS= ',I3,'MMHG  HUMIDITY='  ,I2,' %  '
        1  ,/T6'CAR NO=   ',I1,'         HUMIDITY=  ',I2,'%',
        1   /T25'H     =',I3,'GRAINS H2O/LB DRY AIR')
C
C
```

```
      WRITE(IR3,320)
320   FORMAT(/T30'INPUT DATA'//T8'PARAMETER',7X,'BAG1',6X,'BAG2',
      1       6X,'BAG3',3X,'HIGHWAY'/)
      IF(CAR.EQ.9)GO TO 350
C
C
      WRITE(IR3,330)(GRAMS(I),I=1,4)
330   FORMAT(/T6'FUEL USED',10X,F5.0,5X,F5.0,5X,F5.0,5X,F5.0)
350   CONTINUE
      WRITE(IR3,360)(REVS(I),I=1,4),(VMIX(I),I=1,4),(HCE(I),I=1,4),
      1  (HCD(I),I=1,4),(NOXE(I),I=1,4),(NOXD(I),I=1,4),
      1  (RANGE(I),I=1,4),
      1  (COEM(I),I=1,4),(CODM(I),I=1,4),(CO2E(I),I=1,4),
      1  (CO2D(I),I=1,4)
360   FORMAT(T6,'DYNO REVS',5X,4F10.0,/T6'CVS VOLUME'4X,4F10.0,
      1  /T6'HCE',11X,4F10.3,/T6'HCD',11X,4F10.3,/T6'NOXE',10X,
      1  4F10.3,/T6'NOXD',10X,4F10.3,/T6'CO RANGE',14X,I2,8X,I2,8X,I2,
      1  8X,I2,/T6'COEM',10X,4F10.3,/T6'CODM',10X,4F10.3,/T6'CO2E',
      1  10X,4F10.4,/T6'CO2D',10X,4F10.4)
C
C
C
      WRITE(IR3,410)
410   FORMAT(/T29'CALCULATION DATA')
      IF(CAR.EQ.9)GO TO 418
      WRITE(IR3,415)FUEL(1),FUEL(2),FUEL(3),FUEL(4)
415   FORMAT(/T6'FUEL',10X,4F10.0)
418   CONTINUE
      WRITE(IR3,420)(DREVS(I),I=1,4),FSG,DHC,KH,(COE(I),I=1,4),
    1 (COD(I),I=1,4),(DF(I),I=1,4),(HCMAS(I),I=1,4),
    1 (NOXMAS(I),I=1,4),(COMAS(I),I=1,4),(CO2MAS(I),I=1,4)
420   FORMAT(/T6'DREVS',9X,4F10.0,//T6'FSG=',F6.4,/T6'DHC=',F5.2,
      1  /T6'KH=',
      1  F8.6,//T6'COE',11X,4F10.3,/T6'COD',11X,4F10.3,//T6'DF',
      1  12X,4F10.4,/T6'HCMAS',8X,4F10.3,/T6'NOXMAS',7X,4F10.3,
      1  /T6'COMAS',8X,4F10.3,/T6'CO2MAS',7X,4F10.3)
C
      IF(CAR.EQ.9) GO TO 422
      WRITE(IR3,421)
421   FORMAT(////////////////////////)
      GO TO 430
422   CONTINUE
      WRITE(IR3,423)
423   FORMAT(////////////////////////////)
430   CONTINUE
C
      WRITE(IR3,510) TSTNO
510  FORMAT(/T20'TEST RESULTS SUMMARY',3X,4A2,
      1  /T21'_______________________________'//)
      WRITE(IR3,520)
520   FORMAT(30X'BAG1',10X,'BAG2',10X,'BAG3')
C
C     CONVERSIONS
C
      DO 550 I=1,4
      HCMI(I)=HCBAG(I)*1.60934
      NOXMI(I)=NOXBAG(I)*1.60934
      COMI(I)=COBAG(I)*1.60934
      CO2MI(I)=CO2BAG(I)*1.60934
      FCMI(I)=282.486/FCBAG(I)
      FCUS(I)=235.22/FCBAG(I)
```

```
       IF(CAR.EQ.9) GO TO 550
       FCGVMI(I)=282.486/FCBGRV(I)
      FCGVUS(I)=235.22/FCBGRV(I)
 550   CONTINUE
       HCWMI=HCWM*1.60934
       NOXWMI=NOXWM*1.60934
       COWMI=COWM*1.60934
       CO2WMI=CO2WM*1.60934
       FCWMI=282.486/FCWTCB
       FCWUS=235.22/FCWTCB
       IF(CAR.EQ.9) GO TO 560
       FCWGMI=282.486/FCWTGV
       FCWGUS=235.22/FCWTGV
 560   CONTINUE
       WRITE(IR3,570) (HCBAG(I),HCMI(I),I=1,3)
 570   FORMAT(6X,'HC  G/KM (G/MI)',4X,F6.3,'(',F6.3,')',X,F6.3,
       1  '(',F6.3,')',X,F6.3,'(',F6.3,')')
       WRITE(IR3,580) (NOXBAG(I),NOXMI(I),I=1,3)
 580   FORMAT(6X,'NOX G/KM (G/MI)',4X,F6.3,'(',F6.3,')',X,F6.3,'(',F6.3,
       1  ')',X,F6.3,'(',F6.3,')')
       WRITE(IR3,590) (COBAG(I),COMI(I),I=1,3)
 590   FORMAT(6X,'CO  G/KM (G/MI)',3X,F7.3,'(',F6.2,')',X,F6.3,'(',F6.3,
       1  ')',X,F6.3,'(',F6.3,')')
       WRITE(IR3,605) (CO2BAG(I),CO2MI(I),I=1,3)
 605   FORMAT(6X,'CO2 G/KM (G/MI)',4X,F6.1,'(',F6.1,')',X,F6.1,'(',F6.1,
       1  ')',X,F6.1,'(',F6.1,')')
       WRITE(IR3,610) (FCBAG(I),I=1,3)
 610   FORMAT(/T6,'FUEL CONS. L/100KM',5X,F6.3,9X,F6.3,9X,F6.3,)
       WRITE(IR3,620) (FCMI(I),FCUS(I),I=1,3)
 620   FORMAT(/T6'FUEL ECON MPIG (US)',X,F5.2,X,'(',F5.2,')',2X,F5.2,
       1  X,'(',F5.2,')',2X,F5.2,X,'(',F5.2,')')
 C
 C     FUEL CONSUMPTION PRINTOUT GRAVIMETRIC
 C
 C
       IF(CAR.EQ.9) GO TO 650
       WRITE(IR3,630)
 630   FORMAT(/T8'BAG TEST RESULTS(GRAVIMETRIC)')
       WRITE(IR3,640)(FCBGRV(I),I=1,3)
 640   FORMAT(/T6'FUEL CONS L/100KM'5X,F6.3,9X,F6.3,9X,F6.3)
       WRITE(IR3,645)(FCGVMI(I),FCGVUS(I),I=1,3)
 645   FORMAT(/T6'FUEL ECON MPIG (US)',2X,F5.2,X,'(',F5.2,')'
       1  ,2X,F5.2,X,'(',F5.2,')',2X,F5.2,X,'(',F5.2,')')
 650   CONTINUE
 C
 C     PRINTOUT OF WEIGHTED TEST RESULTS
 C
 C
       WRITE(IR3,700)
 C
 700   FORMAT(///T8'TEST RESULTS WEIGHTED CITY,AND HIGHWAY',//T31'
       1  CITY',10X,'HIGHWAY'/T7'EMISSIONS')
       WRITE(IR3,710) HCWM,HCWMI,HCBAG(4),HCMI(4)
 710   FORMAT(/6X'HC  G/KM (G/MI)',4X,F6.3,'(',F6.3,')',3X,F6.3,
       1  '(',F6.3,')')
       WRITE(IR3,720) NOXWM,NOXWMI,NOXBAG(4),NOXMI(4)
 720   FORMAT(6X,'NOX G/KM (G/MI)',4X,F6.3,'(',F6.3,')',3X,F6.3,
       1  '(',F6.3,')')
       WRITE(IR3,730) COWM,COWMI,COBAG(4),COMI(4)
 730   FORMAT(6X,'CO  G/KM (G/MI)',4X,F6.3,'(',F6.3,')',3X,F6.3,'('
       1  ,F6.3,')')
       WRITE(IR3,740) CO2WM,CO2WMI,CO2BAG(4),CO2MI(4)
 740      FORMAT(6X,'CO2 G/KM (G/MI)',4X,F6.2,'(',F6.2,')',3X,F6.2,'
          1  (',F6.2,')')
          WRITE(IR3,750)
 750      FORMAT(/T7'FUEL CONSUMPTION /ECONOMY',//T6'(FROM CARBON',
          1  1X,'BALANCE)')
          WRITE(IR3,760) FCWTCB,FCBAG(4)
 760      FORMAT(/T6'FUEL CONS L/100KM',5X,F6.3,11X,F6.3)
          WRITE(IR3,770) FCWMI,FCWUS,FCMI(4),FCUS(4)
 770      FORMAT(/T6'FUEL ECCN MPIG (US)',X,F5.2,X,'(',F5.2,')',5X,
          1  F5.2,X,'(',F5.2,')')
          IF(CAR.EQ.9) GO TO 830
          WRITE(IR3,780)
 780      FORMAT(//T6'(FROM GRAVIMETRIC),')
          WRITE(IR3,790) FCWTGV,FCBGRV(4)
 790      FORMAT(/T6'FUEL CONS L/100KM',5X,F6.3,11X,F6.3)
          WRITE(IR3,800)FCWGMI,FCWGUS,FCGVMI(4),FCGVUS(4)
 800      FORMAT(/T6'FUEL ECON MPIG (US)',X,F5.2,X,'(',F5.2,')',5X,
          1  F5.2,X,'(',F5.2,')')
 830      STOP
          END
```

APPENDIX N

Vehicle #3 Automatic Idle Speed Maintenance Calibration Specifications

VEHICLE NO. 3 AUTOMATIC IDLE SPEED

Maintenance Calibration Specifications

1. General

Engine - Displacement	1.7 L
- Compression Ratio	8.2:1
Transmission	3 Speed Auto
Axle Ratio	3.48:1
Carburetor	Holley S220 Series Chrysler P/N S214324

2. Carburetor Specifications *

Idle Speed (RPM)	900
Propane Enriched Idle Speed (RPM)	1000
Hot Fast Idle Speed (RPM)	
Vacuum Kick	0.040"
Choke Index	2 notches Rich

* For Detailed Tuneup Procedure See Appendix 2.

Electronic Spark Advance Specifications

Maintenance Calibration

General	Prom "Service"
Crank Advance	10
Basic Advance	15
Coolant Sensor (Thermistor Type)	Yes
Vacuum Accumulator (Clock)	Yes
Maximum Advance	55°
Start to Run Speed (RPM)	600
Run to Start Speed (RPM)	200

Governor Advance

(Degrees @ RPM)	0° @ 1200 10° @ 2000 20° @ 6000

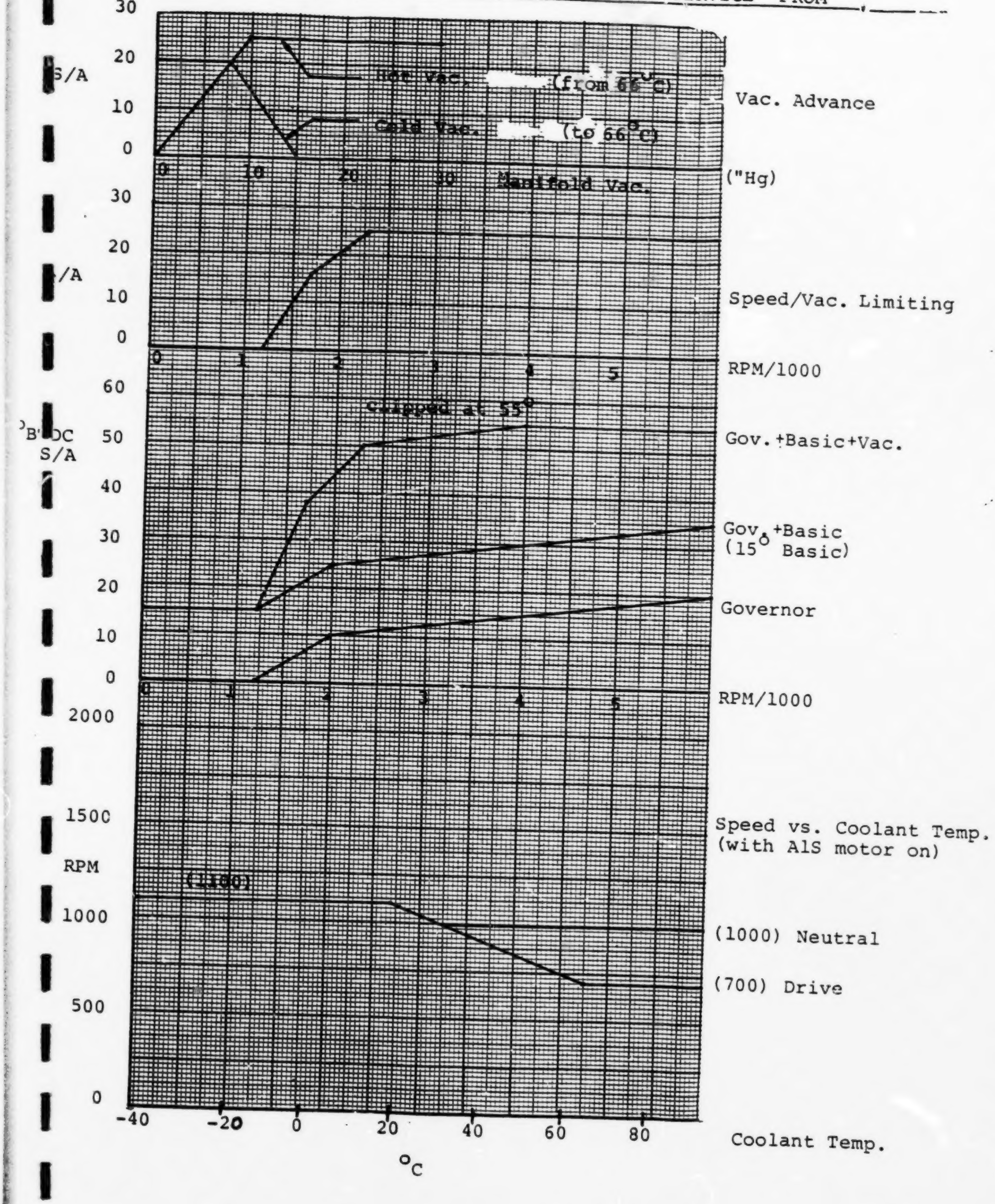
Cold Vacuum Advance

(Degrees @ "Hg Vacuum)	20° @ 0" 20° @ 8" 0° @ 15"

(cont'd)

Cold/Hot Vacuum Transition (°C)	66°
Hot Vacuum Advance	
(Degrees @ "Hg Vacuum)	0° @ 0" 25° @ 10"
Speed/Vacuum Limiting Curve	
(Applies to Hot Vacuum Advance Only)	
(Degrees @ RPM)	0° @ 1200 16° @ 1700 25° @ 2300
Vacuum Accumulator	
(Applies to Hot Vacuum Only)	
Zero Time Offset	99%
Count Up Time (secs)	1
Count Down Time (secs)	1
Automatic Idle Speed	
Idle Speed Range (RPM)	±5
(RPM @ °C Coolant Temp.)	
Drive	1100 to 21° 700 from 66°
Neutral	1100 to 21° 1000 from 32°
Hot Start RPM (Drive)	1000 for 10
(RPM for Seconds)	
Throttle Kick RPM (Drive)	750 for 1
(RPM For Seconds)	
Decel Kick Speed (RPM)	1200
Cold Start Kick Temperature (°C)	38°

VEHICLE #3 - AUTOMATIC IDLE SPEED "SERVICE" PROM



POOR

QUALITY

ORIGINAL